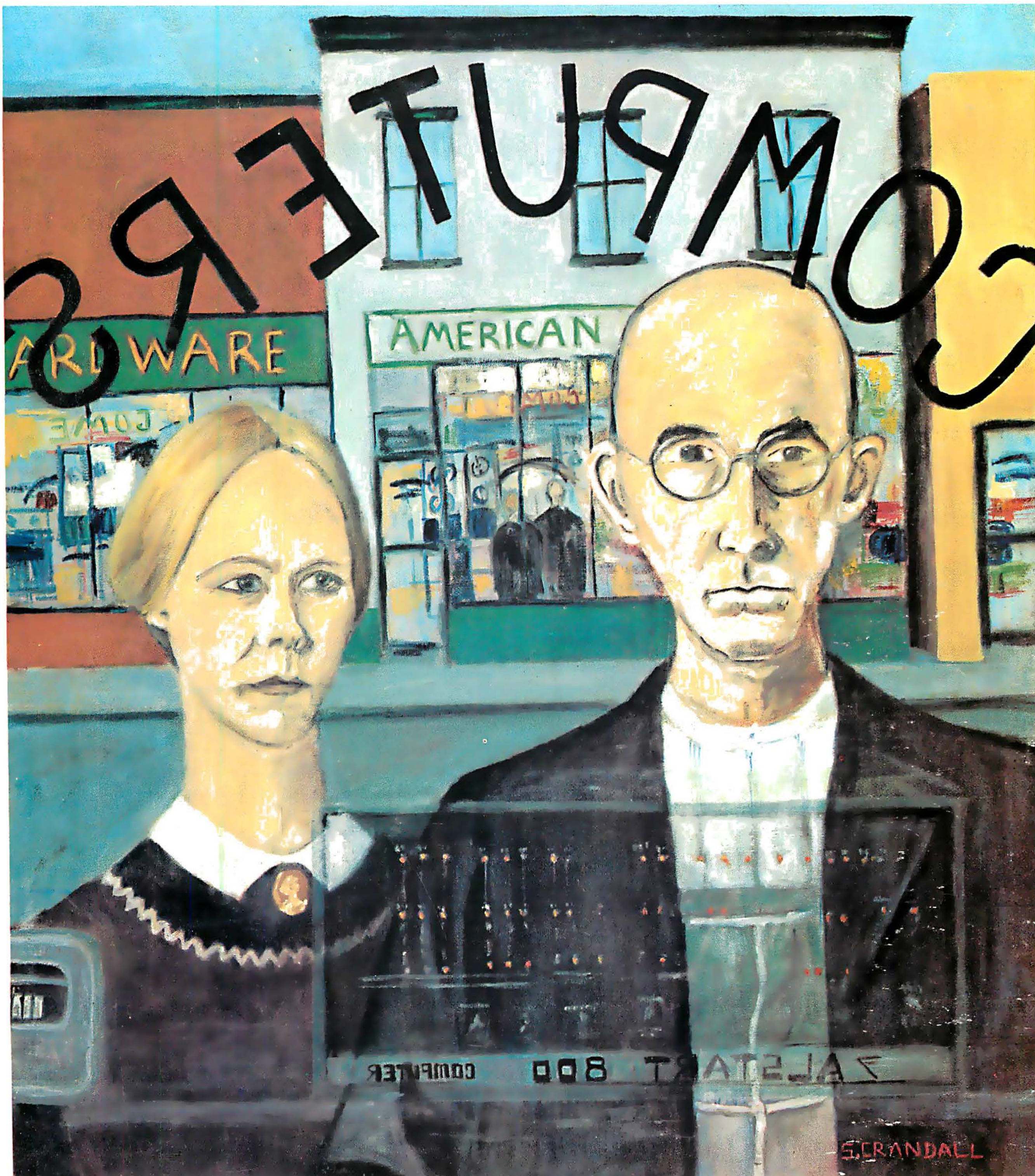
MARCH 1977 VOLUME 2, Number 3 $1.50

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BYTE

the small systems journal



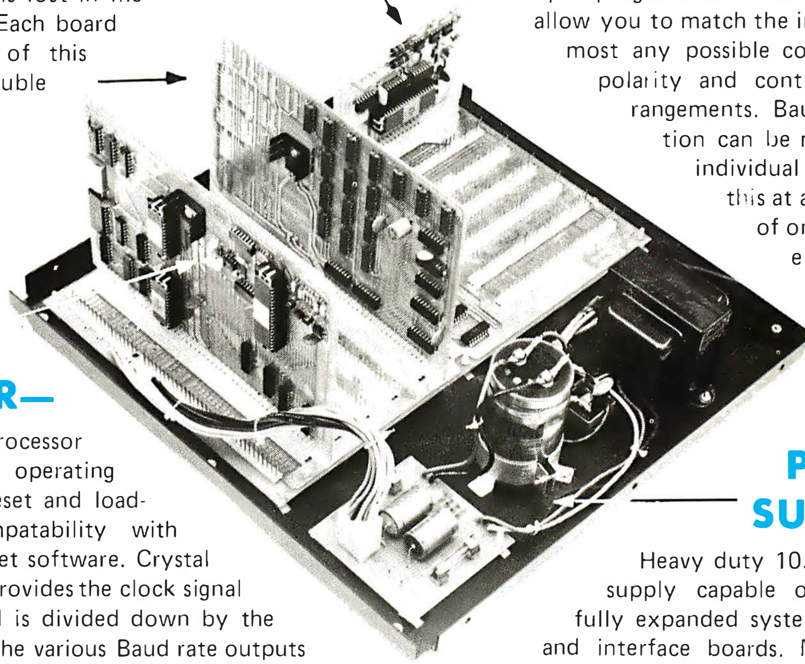
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- The S-100 bus that's widely supported by a host of peripherals manufacturers.
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- Card retainer to secure cards in sockets under all conditions.
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DEDICATED APPLICATIONS

The new Z-2 is specifically designed as a powerful but economical dedicated computer for systems work. Notice that the front panel is entirely free of controls or switches of any kind. That makes the Z-2 virtually tamper-proof. No accidental program changes or surprise memory erasures.

(For your custom work, Cromemco will supply blank panels.)

4 MHz SPEED

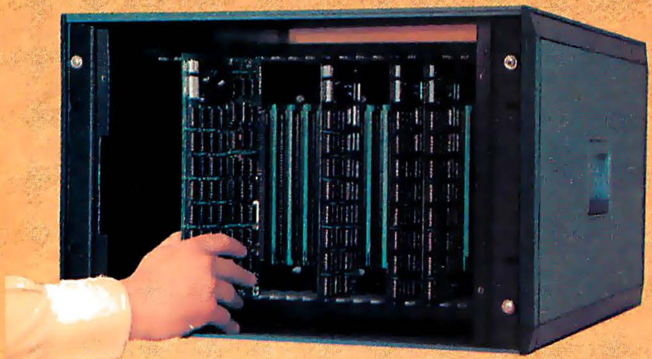
Cromemco's microcomputers are the fastest and most powerful available. The 4 MHz speed of the Z-2 means you get about twice the speed of nearly any other microcomputer.

(continued on next page)



Cromemco

OVER



Full-width motherboard has slots for 21 cards.

That 4 MHz speed cuts running time in half — cuts your waiting time in half. Lets you do more sophisticated work that might not otherwise be practical with a microcomputer.

Z-80 GIVES MORE COMPUTER POWER

The Z-2 uses the powerful Z-80 microprocessor with its 158-instruction set, 19 internal registers, 10 addressing modes, and 16 bit arithmetic operations.

The Z-80 is widely regarded as the standard microprocessor of the future. So you're in the technical fore with the Z-2. But you can also plug in other microprocessor boards if you wish.

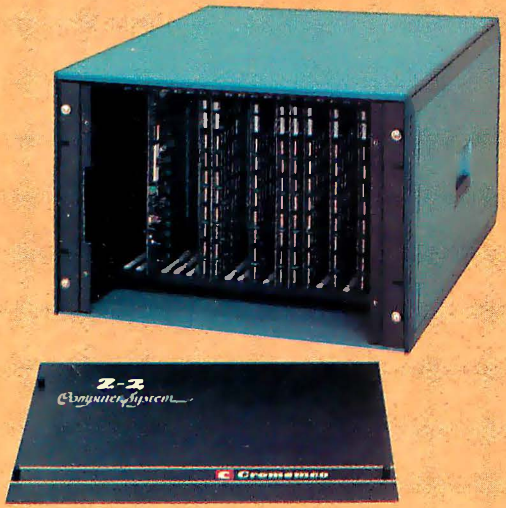
BROAD SOFTWARE SUPPORT

Since the Z-2 uses the Z-80, your present 8080 software can be used with the Z-2. In addition, Cromemco also offers software support including a monitor, assembler, and a BASIC interpreter.

STANDARD S-100 BUS

The Z-2 uses the S-100 bus that has become standard in the microcomputer field. Dozens of manufacturers support it with compatible peripherals.

Of course, all Cromemco peripherals such as our 7-channel A/D and D/A converter, our well-known BYTESAVER with its built-in PROM programmer, our color graphics interface, etc., will also plug into the bus.



Z-2 is supplied for rack mounting. Attractive bench cabinet shown is also available.

LOW NOISE

Cromemco engineers have been careful to design the Z-2 for reliable operation at its fast 4 MHz speed. Noise on the motherboard, for example, has been carefully minimized by a unique ground-plane design (we call it our 'Blitz Bus™'). With this bus you won't get erratic operation due to ground current noise.

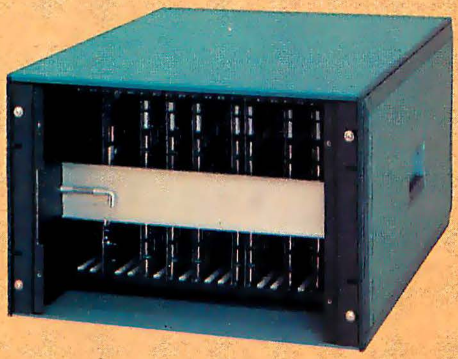
RACK OR CABINET MOUNTING

The basic Z-2 is supplied in a black-anodized metal case for mounting in a standard 19-inch relay rack. A high-quality stylized bench cabinet in an attractive blue color is also available.

KIT OR ASSEMBLED

You can get the Z-2 either kit or assembled. The kit includes the Z-2 for rack mounting, the Cromemco 4 MHz microprocessor card, full-length 21-card-slot motherboard, power supply, one card socket and card-guide set, and front panel.

The assembled Z-2 includes the above as well as all 21 sockets and card guides and a cooling fan.



Heavy-duty retainer bar insures that cards won't jostle out of sockets.

LOW, LOW PRICE

All who've seen the Z-2 have been surprised and impressed with its low price.

You'll be impressed, too, with its technical excellence and quality.

So see it right away at your computer store — or order now directly from the factory.

The sooner you put this advanced computer to work for you, the sooner you'll be solving problems and saving time/money.

Z-2 Computer System kit (Model Z-2K) . . . . . $595.
Z-2 Computer System assembled
(Model Z-2W) . . . . $995.

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In the Queue

Foreground

Background

Nucleus

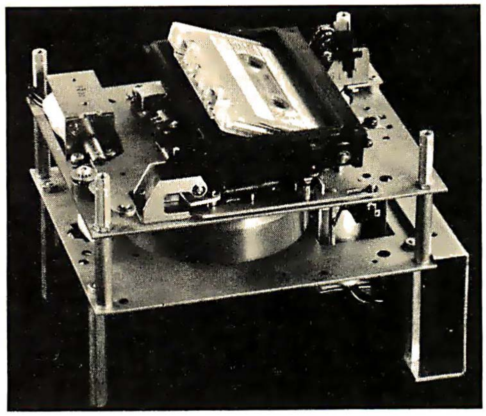
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Number 3



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About the Cover

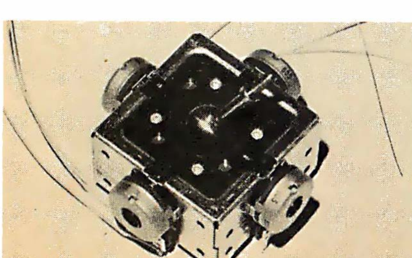
This month's cover is by Sandra D Crandall, Narragansett RI 02882, a first prize winner of BYTE's Computer Art Contest. When she painted her updated "American Gothic," she was completing her BFA in Art at the University of Rhode Island, and as assistant Art Department slide curator, maintained a library of over 40,000 slides. "My fiance is finishing his BS in Computer Science and is an avid BYTE subscriber from the word go," she wrote.

In This BYTE

Many of the possible applications of small computers involve the moving of a mechanical device. One possible way to digitally control these devices is with servomechanisms such as those used in radio controlled model aircraft. In his article, **Give Your Micro Some Muscles**, Robert D Grappel describes how simple it is to interface these devices with your computer to control your own mechanical devices.

Since microprocessors have hit the hobby market, one of the larger difficulties of the computer hacker has been obtaining inexpensive hardware copy capabilities. Southwest Technical Products Corp has introduced a line printer that is the answer to this difficulty. Their inexpensive impact dot matrix printer is described by Gary Kay in his article **A Review of the SWTPC PR-40 Alphanumeric Printer**.

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The audio cassette is a kluge similar to paper tape; it works but is inconvenient. The "ideal" cassette system is completely controlled by the computer's commands, the full digital cassette recording facility. In his article on **Cassette Transports for the "Roll Your Own" Hobbyist**, William H Freeman takes a look at three different drives which have potential as mass storage subsystems for the personal computing experimenter.

Last month we began an article on **The Digital Cassette Subsystem**, by Jack Breimeir and Ira Rampil. In this issue, we continue the discussion with part 2, concerning digital data formats and system considerations.

Today's computer hobby world is a kit oriented one. In his article, **Kit Building for the Computer Hobbyist**, Louis E Frenzel sets forth guidelines that allow the inexperienced kit builder, the inexperienced hardware person, or the software hacker who just wants to get the basics, to construct a working computer oriented kit on the first attempt.

Navigation has come a long way since the astrolabe, as exemplified by the Omega system. In this month's BYTE, Ralph W Burhans continues his presentation of the hardware for an inexpensive Omega navigation system with some **Simplified Omega Receiver Details**. (The series concludes with an article on software by Richard J Salter Jr in next month's BYTE.)

To interact with video games or graphic systems, it is often useful to interface devices such as joysticks to the microprocessor. In his article, **An Inexpensive Joystick Interface**, Thomas Buschbach describes one method that will enable you to implement the conversion process in hardware.

Over the years since the demise of the original Star Trek television series, there has been an increasing variety of people enamored with the ideas that the program had to offer. Among these people are personal computing enthusiasts who have turned these ideas into a large variety of computer games. In **Flights of Fancy with the Enterprise**, David Price introduces his own version of the Star Trek theme. His program, though small enough to be played on many microcomputers, allows a wide enough number of variations in play to satisfy even the most frequent users. This program is a must for Trekkies.

Steve Ciarcia owns and uses a Digital Group 8080A system. Read about his experiences and you might want to **Try This Computer on for Size.**

Want 16 digit BCD output for your calculator software? Need an octal display to replace your binary lamps? Read Jim Hogenson's article on how to **Multiplex Your Digital LED Displays** to find out what it takes to make numeric display output hardware.

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Sol Systems put it all together. One source for hardware and software. One source for engineered compatibility of computer and peripherals. That's the Sol plan.

Though the microprocessor made the powerful small computer possible, a lot of folks found out early efforts in the marketplace were selling the sizzle a lot more than the steak. After an initial investment of several hundred dollars, you ended up with some nice parts, but no memory of any kind, no I/O devices or interfaces, no display, printout or software.

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There are no surprises. Everything you need to make it work is here. In kit form, nominal assembly time from our fully documented instructions is four to seven evenings.

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You can begin your Sol system with the all on one board Sol-PC kit. It has all the memory and interface electronics including video display, keyboard interface, audio cassette interface, all necessary software and the ability to accept the full Processor Technology line of memory and interface modules. Use the Sol-PC as the basis of a microcomputer, low cost CRT terminal or editing terminal

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By filling the basic main frame with tailor made Processor Technology plug-in PC boards, you can really expand the computing power and flexibility of your Sol-20 Personal Computer.

New items are being announced frequently, but right now, here are some of the things you can add to your Sol-20. The ALS-8 Firmware module is an assembly language operating system to give you the power to develop and run programs. Use it to quickly write, edit, assemble, de-bug and run your own programs. Some say it's the most useful software development on the market today, but modesty prohibits.

And when it comes to add-on memory boards, you've come to the right place. We've probably got more than anyone else. Choose from 2K ROM or 4, 8 or 16K RAM. The PT 2KRO will accept up to eight 1702A or 5203Q erasable, reprogrammable memories (EPROM's) with the ability to store in a non-volatile fashion up to 2048 eight-bit words.

Our read/write memories are the industry standards for high reliability. We know, because we have literally scores of customer letters saying "Your memory modules work and keep on working."

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No computer can do the full job without the right set of peripheral gear. PT has



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sought out the best manufacturers of peripheral equipment and worked with them to give you a choice of quality so you can get the most out of your Sol-20. Choose from line and serial printers, perforated tape readers and punches, floppy disk memories, black and white or color graphics displays, A/D, D/A converters and more.

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A big part of making the first complete small computer is providing you with a wide range of easy to use, easy to obtain, low cost software. For the Sol-20, we've developed a whole group of offerings. And more are on their way.

Sol Systems Price List

(prices are net, effective Dec. 1, 1976)

SOFTWARE

ITEM with manual	Source	CUTS cassette	Paper tape
BASIC 5 software #2	yes	**	$19.50
8K BASIC	no	$29.00	$37.00
New 8080 Focal	no	$14.50	N/A
TREK 80 video game	no	$ 9.50	$14.50
GAMEPAC 1 video games	no	$ 9.50	$14.50
MATHPACK video calculator	yes	$14.50	$19.50
ASSEMBLER software #1	yes	$14.50	$19.50

**CUTS cassette of BASIC 5 is included FREE with all orders for Sol units or CUTS cassette interfaces. Additional cassettes available for $14.50.

Sol system owners be sure to note Sol system on your order. These special versions use less code and provide easier loading along with more convenient operation. SOLOS, SOLED and CONSOL all have provision for the special versions.

All Processor Technology software is distributed on an individual sale basis for personal use. No license to copy, duplicate or sell is granted with this sale. Each software package has been copyrighted by Processor Technology and all rights therein are reserved.

Sol Terminal Computers	Kit Price
SOL-PC SINGLE BOARD TERMINAL COMPUTER™	$475.*
SOL-10 TERMINAL COMPUTER™ Sol-PC with case, power supply and 70 key solid state keyboard.	$795.*
SOL-20 TERMINAL COMPUTER™ all features of Sol-10 with larger power supply, 85 key solid state keyboard, fan, and five slot expansion backplane.	$995.*

*Sol prices include CONSOL Personality Module. If SOLED Intelligent Editing Terminal Module or SOLOS Standalone Operating System Module is desired instead, add $100. If ordered separately, personality modules are $150 each.

Mass Storage Systems		
Helios II Disk System™ includes dual PerSci 270 floppy disk drive, cabinet, fan, S-100 bus compatible controller, power supply, system diskette with complete PTDOS software	$1895	$2295

Memory Modules	Kit	Asmbld.
ALS-8 PROM Resident Assembly Language Operating System	—	$425
SIM-1 Interpretive Simulator add-on option for ALS-8	—	$ 95
TXT-2 Text Editing add-on option for ALS-8	—	$ 95
2KRO Erasable PROM module	$ 65	$ 89
4KRA 4096-word Low Power Static RAM	$159	$195
8KRA 8192-word Low Power Static RAM	$295	$375
16KRA 16384-word Dynamic RAM	—	$529
Interface modules		
3P+S Parallel/Serial I/O module	$149	$199
CUTS Computer Users Tape System cassette interface	$ 87	$119
VDM-1 Video Display Module	$199	$295

See your nearest dealer or contact us directly. Address Processor Technology, 6200B Hollis Street, Emeryville CA 94608, Phone 415/652-8080.

Processor Technology Corporation

Give Your Micro Some Muscles

Robert D Grappel
148 Wood St
Lexington MA 02173

A lot of proposed microcomputer applications require the computer to control various mechanical devices. Opening and closing valves, moving things, pushing, turning, etc, are not things that computers can do without help. This article describes a surprisingly easy way to turn digital signals into mechanical motion. This will make it easier to design plotters, controllers . . . anything that requires motion.

Before I was bitten by the "computer bug," my hobby was building radio controlled aircraft. In trying to solve the problem of transferring the position of the pilot's hand to the position of a control surface on the aircraft, we modelers gradually came to use digital systems. The servomechanisms used in aircraft are very sophisticated devices. They are tiny, less than 3 cubic inches (49 cubic centimeters). They are light, less than 2 ounces (58 grams). They provide up to 4 pounds (1.8 kilograms) of thrust. Each servo requires less than 200 mA of current at 5 V. They continue to work over a wide temperature range and in conditions of extreme vibration. It seems to me that such devices would make ideal muscles for our computers. Servos are readily available, and are relatively cheap at around $25 to $50. How does one interface an aircraft servo to a micro? Would you believe three connections? Yes, it really is that simple.

You will want to use what is called a

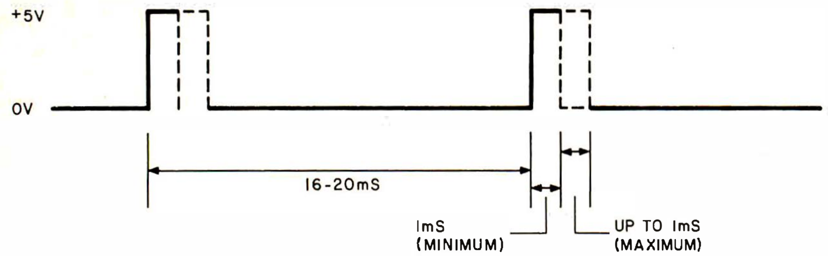


Figure 1: Timing diagram of the waveform that is needed to drive the servomechanism. The pulses are from 16 to 20 ms apart in time, and have a pulse width of 1 to 2 ms. This type of timing can be accomplished using your computer's internal clock as a reference in timing loops, or through a programmable real time clock.

three wire servo which is the modern type unit. These run on regulated 5 V supplies. That takes care of two of the necessary connections. The third lead is the input signal. This is a TTL compatible signal, which can be driven from one bit of a typical output port. We will use software to generate the proper waveform at this bit. Since each servo requires only one output bit, a typical byte port can drive up to 8 servos.

Servos are really pulse width feedback

```
LOCN B1 B2 B3
2001          >     ORG $2001
2001          >* PROGRAM TO TEST MODEL AIRPLANE SERVO
2001          >*    WRITTEN BY CARL HELMERS 12/8/76
2001          >*    ASSEMBLED WITH JACK EMMERICHS' ASSEMBLER
2001          >*    ILLUSTRATION FOR ROBERT GRAPPEL'S ARTICLE
2001          >*
2001          >* --------------------DATA DEFINITIONS--------------------
0151          >PIAC EQU  $151    PIA CONTROL REGISTER ADDRESS
0150          >PIAD EQU  $150    PIA DATA/DIRECTION REGISTER ADDRESS
0138          >MILI EQU  $138    MILI(B)  MILLISECOND DELAY ROUTINE
2001 00 00    >DATA FDB  0       SERVO POSITION DATA REGISTER
014F          >LAMZ EQU  $14F    LAMPS
2003          >*
2003          >* ------------------------PROGRAM-------------------------
2003          >* MAIN ENTRY POINT
2003 7F 01 51 >ENTY CLR  PIAC    SET UP THE PIA
2006 7F 01 50 >     CLR  PIAD        WITH ALL DATA
2009 73 01 50 >     COM  PIAD            BITS OUTPUT
200C 86 04    >     LDAA #4
200E B7 01 51 >     STAA PIAC
2011 7F 01 50 >     CLR  PIAD    POSITIVE GOING PULSE SETUP
2014          >*
2014          >*  MAIN EXECUTION LOOP
2014          >*
2014          >* PULSE OUTPUT, MINIMUM 1 MS
2014 73 01 50 >PULS COM  PIAD    START PULSE
2017 C6 01    >     LDAB #1      WAIT ONE
2019 BD 01 38 >     JSR  MILI       MILLISECOND
201C B6 20 01 >     LDAA DATA    ---
201F 4A       >PULI DECA            VARIABLE DELAY
2020 26 FD    >     BNE  PULI                    ---
2022 73 01 50 >     COM  PIAD    END THE PULSE
2025 C6 FA    >     LDAB #250     ---
2027 BD 01 38 >     JSR  MILI      250 MS INTERPULSE DELAY
202A 7C 20 01 >     INC  DATA
202D B6 20 01 >     LDAA DATA
2030 B7 01 4F >     STAA LAMZ
2033 20 DF    >     BRA  PULS
2035          >     END


*** END - UNRESOLVED ITEMS:


*** SYMBOLS:

DATA 2001  ENTY 2003  LAMZ 014F  MILI 0138  PIAC 0151
PIAD 0150  PULI 201F  PULS 2014  #
```

Notes on Trying Robert's Idea for Muscles

by Carl Helmers, editor

Using the servo we bought to take the picture of photo 1, I wrote the program shown in this listing to illustrate the operation and test out the characteristics of the device. The program is written for my homebrew 6800 system, which has parallel interface ports at hexadecimal addresses 150 to 157 in memory address space. The PIA port at locations 150 and 151 was used for this experiment, with some binary indicator lamps at location 14F used to tell what the current state of the command parameter was. This program uses a subroutine in my monitor called MILI which is a timing loop returning to the calling point 1 millisecond after entry. The interpulse space was arbitrarily set at 250 ms (it worked) in order to allow observation of what was happening

Continued on page 34



Photo 1: A typical model aircraft servo, which we purchased at a local hobby shop in Greenville NH. The price of this unit was about $45, and the only documentation we could find on it, the catalog, said it could exert 5 pounds of force, presumably at the limit of the lever arm provided by the standard bell cranks and connection wheels which came with it. We took it apart after photography and found a gearbox with several gears, the motor, potentiometer slaved to the main output shaft, and electronics. Although the printed circuit board internal to the device had "made in Japan" marked on it, the actual integrated circuit was clearly a result of international trade — it was marked "Texas Instruments." After reassembly, it was tried out with the program shown in the box accompanying this article, using a PIA port at address location 0150 (hexadecimal).

units. The input is a pulse with a carefully controlled width. The servo contains an electric motor, a gear train, a feedback potentiometer connected to the gearing, and some fairly sophisticated electronics. In modern servos, all the electronics is contained in a custom integrated circuit. The circuit generates an internal pulse every time it receives an input pulse. The internal pulse width is controlled by the feedback pot. The circuit then compares the pulse widths. If they match, then no current goes to the motor. If they do not match, then current is fed to the motor and it drives the mechanics, together with the feedback pot, in the appropriate direction until the pulse widths again match. By feeding pulses in a rapid stream into the servo, it will appear to track the varying pulse width.

Just about every servo sold for use in model aircraft expects pulse widths varying between 1 and 2 ms. Most servos use positive going pulses, but there are a few servos around which require negative going pulses. The pulses should be repeated every 16 to 20 ms. The repetition frequency is not critical. The servo will run from extreme to extreme in about 0.5 s. To drive the servo, one then needs to generate a waveform like that in figure 1. This can be done with timing loops, interrupts or programmable timers. Even the slowest processor can handle this task.

Model boats, and some aircraft, use electric power plants. The same type of controls can be used to vary the speed and direction of electric motors. For readers interested in controlling motors, and other high power devices, I would recommend the circuits published in *RCM,* (Radio Control Modeler). Page 166 in the April 1976 issue shows a circuit using the integrated circuit from a servo and two external transistors to control a 20 A motor from full stop to full speed. Page 12 of the September 1976 issue shows a similar circuit which has the added feature of forward and reverse control. Circuits like these can also control other loads, like lights or heaters. This is fully proportional control, not just on and off.

Now there is no excuse for not building that robot you were thinking about. You can use servos to control your tape cassettes by pushing the buttons under computer control. Using two servos, one in the X direction and another in the Y direction, a pen plotter can give your computer a hard copy graphics capability. There are hundreds of exciting possibilities. I hope to read of some of them in these pages soon.■

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PAPERBYTES™ Forum

Machine readable printed software is an exciting subject. Numerous comments have been received from various individuals regarding the idea of machine readable printed software as described in the November and December 1976 issues of BYTE. These are excerpts from various letters which often covered other topics as well:

Multiple Synch Characters . . .

Several people have suggested that the format should contain multiple SYN characters. Here are a couple of examples of the comments:

I have a few comments on the proposed standard for machine readable printed data. (My forte is not building bar code readers, but I do have some experience in high speed data transmission.) In the proposed frame layout I would suggest duplicating the SYNCH character at least one more time, and possibly a couple more times. The reasoning is that even if the timing marks are included (which I don't think were in the December samples) the adaptive algorithm must establish "bit synch" to extract the bits correctly, and then it must establish "character synch" to insure it has gotten the character boundaries correct. In data transmission schemes, usually two or four synchs are used depending on whether the synch pattern is to establish only character synch or both character and bit synch. The modulation schemes you have presented seem to have enough transitions in them to get bit synch, so four synchs probably aren't needed. But the algorithm would be a lot more sure of what is going on if there were at least two synchs: one to get synched, and one to check the synch. I think this is particularly important considering the data following the synch is the checksum. Slop or jitter from the startup of the human hand could be particularly damaging here. A few extra synchs thrown in could solve that potential problem.

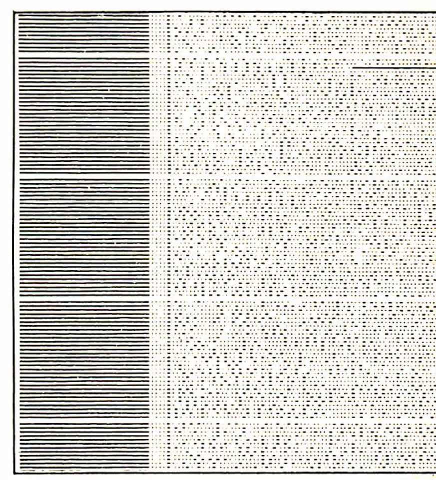
Maybe I am trying to make this all too complicated, but my background is one of insuring robustness in protocols. The bar code wand reader experts probably have a better feeling than I for things like this.

Mike O'Dell
University of Oklahoma
Information and Computing Sciences
601 Elm, Rm 926
Norman OK 73069

Another reader suggested putting a second SYN character at the end of the frame in order to allow scanning in either direction, a sentiment which was echoed by Tom Pittman of Tiny BASIC fame. But using the sparse format shown in the examples in this issue [or format (c) of December BYTE, page 17], the frame capacity is only about 26 to 32 data bytes, depending on length, so a 3 to 4% penalty in capacity is required. Also, the main advantage is to allow sweeps in both directions, which for manual scanning may not be particularly important since the rhythm of operation has to be interrupted by repositioning the guide straightedge between each swipe.

Printed, Machine Readable Braille?

Totally unrelated to our bar code representation for data, but nevertheless interesting, is this letter from C R Conkling Jr, and his accompanying sample.



The sample is a short segment of the text, reproduced here twice the original size, which was a test occupying two sides of a letter size sheet of enameled paper.

I was interested in your thoughts on using ink print to transmit digital information. I have enclosed an ink printed sheet of paper which was printed using standard offset methods. The paper contains a complete pocket paperback size book. I must say, however, that it is in grade 2 Braille which uses contractions, as in speed writing. The Braille code is a 6 bit code, and the paper is encoded to drive a mechanical Braille cell to reproduce the data.

Why it was done is a long story. Why it was never completed is even longer. One of the reasons that it was never completed was that we had no luck

Continued on page 82

Editorial

BYTE Goes International

by Carl Helmers

Accompanying this editorial is a letter from an Australian reader, Kevin C Barnes of Five Dock, New South Wales. He's writing on the conditions of the small computer person in Australia circa September 1976. We held onto the letter until it was possible to announce an arrangement which should help promote and build an indigenous small computer industry in Australia: the new Far East Asian editions of BYTE magazine.

When BYTE first began circulation, an electronics engineering consultant named John Bannister, a native of Sydney, Australia, subscribed nearly instantaneously when he heard about it from an American friend. But he soon ran into a problem which plagues all individuals on the end of a long international supply chain — it takes time and patience to await BYTE (or any US goods, for that matter) in Australia, which is

Continued on page 62

Are Logic States Inverted Down Under?

Here are just a few notes that might be of interest to your readers about conditions in Australia. Interest in computing is just about to happen down here. Both national electronics magazines, *Electronics Australia* and *Electronics Today International* have just (July 1976 issue) started to talk about microprocessors. They have started by reviewing the different evaluation boards available. But neither magazine has published any construction articles as yet on microprocessor based microcomputers. (*EA* did design and publish an 8 bit processor back in the end of 1974 and beginning of 1975, but it was a serial processor which did not gain the popularity of the present microprocessor systems. That processor, the EDUC-8, was built using TTL MSI and SSI chips and had a limited memory of 256 locations. In fact *EA* was beaten to the honor of being the first to publish a computer plan by only a few weeks by *Radio Electronics'* publication of the Mark 8.)

Commercial interests now have a number of American designed and built systems offered for sale, but unfortunately these people do not yet carry much stock. MITS equipment is offered down here by a company called WHK of Melbourne, and the proprietor has published a rather impressive catalog with all the MITS hardware and software listed. JOLT is also being advertised as well, although mainly through the trade journals. EPA's Micro 68 also has been offered for sale and the agent has at least one in stock which he is willing to lend to people to look at and play with.

I and three other people have formed a small club and have three systems operating, using the 6800, 8080 and the SC/MP chips. They have been built around evaluation boards. We also have an ASR-33 and ASR-38 Teletype and our big project at the moment is a floppy disk. Our small project of the moment is a PROM programmer to program 1702s. In my conversations with various integrated circuit manufacturing company representatives, I've gained information that a good proportion of the sales here have been to individuals, not companies, and that many boards bought by companies have been for individuals within the companies and not for particular company projects [*standard practice in the US, too . . .* CH].

Also very annoying is the rather high price markup on the hardware by the time it reaches Australia. The *Intel 8080 Microprocessor System User's Manual* for instance has sold for $20 even though it is marked $5, while the Altair 8800A sells for $619 Australian ($740 US currently) for the basic kit with no extra boards. Well, I hope this has been of interest.

Kevin C Barnes
71 Barnstaple Rd
Five Dock
New South Wales 2046
AUSTRALIA

Thanks for your comments, Kevin. By the time this letter is in print, it will be part of the third issue of our new Australian English language edition of BYTE, so with any luck you'll soon start to find some increases in personal computing activity in your vicinity. Until there is local manufacture, there is no way you can beat the price penalty, as nearly as I can project: Shipping costs time and money. When a product is dear, whether through distance or natural scarcity, Adam Smith and Co long ago predicted the price would rise. I understand from John Bannister, however, that at least you don't have to pay an exorbitant import tariff as our Canadian friends do.

Letters

8080 TRICKS AND FAST OPTICS FOR ISOLATION

In the November 1976 letters column, reader Bennett asked for an easy way to do an arithmetic shift right using the 8080. Try RLC, RAR, RAR; only three bytes, and the carry bit ends up the same as with SRA A on the Z80.

By the way, if anyone wants to try an optically coupled video interface to a television, look at HP's 5082-4360 optically coupled logic gate. It's rated for 10,000 bits per second and costs $6.30 in unit quantity. Cheaper optical couplers can handle sync and, if necessary, an on/off control, but the HP device is the first one I've seen that looks fast enough to handle video frequencies. Using a separate device for sync avoids critical biasing adjustments to make a single device operate in the linear mode. With separate devices, the video and sync mixer goes on the output side of the devices. Frequency response can go down to DC if you can avoid upsetting the television's video stage bias without using a DC blocking capacitor.

Robert F Miles
242 Abingdon Rd NW
Lenoir NC 28645

OOPS . . . SUPPLIES GONE

After reading the "An Item of Interest" article in the September issue of BYTE (page 100), I wrote to SWTPC for the June 1976 newsletter. But the newsletter is not in print anymore.

Is there any way I could get a used or old June 1976 newsletter? Please respond.

Robert Leong
705 N Linden Dr
Beverly Hills CA 90210

WANTED: ELIZA FOR THE SMALL COMPUTER

Many years ago I had a dialog (my first online experience!) with a computer that conversed like a psychiatrist, selecting phrases from my input and feeding them back in new context or, if nothing good suggested itself, injecting a random phrase such as "how did you feel about your father?". It was called the ELIZA program, because it learned from its input. According to one article I have read, it was originated at MIT.

Now, after considerable timesharing, I am a subscriber to BYTE and am buying an Altair 8800a on the Kit-a-Month plan. Is anyone in BYTEland familiar with the software for ELIZA? In particular, does anyone know of a version suitable for small machines? I'll try to reinvent it if I must, but it seems silly to do so.

John P Aurelius
2568 10th Av W
Seattle WA 98119

ELIZA is a program created by Joseph Weizenbaum at Massachusetts Institute of Technology, which has since spread somewhat widely – in ways not necessarily consistent with its creator's goals. See BYTE's review of Weizenbaum's book, Computer Power and Human Reason, *on page 11, January 1977. The book is highly recommended reading for any intellectual. As to whether detail implementations of ELIZA style programs can be found, maybe a reader with academic connections can enlighten us.*

THAT'S THE RIGHT IDEA . . .

I'd like to give my support to Charles Wortell's entry to the Programming Quickies column [December 1976, page 132]. A few months ago I thought of presetting memory of my 6800 system to SWI (hexadecimal 3F) to catch wayward programs. I'd like to suggest the following to anyone considering a ROM operating system for a 6800: I've replaced the MIKBUG monitor in my SWTPC 6800 with a PROM monitor that initializes memory to SWI. This is only done on power up reset and not on subsequent resets.

I've changed all interrupt vectors to addresses in the processor board RAM. This allows faster interrupt service and frees the SWI for alternate uses. As an added bonus an unexpected interrupt from IO will cause a register print just like SWI.

I'd welcome correspondence from readers considering this and other routines I included in my monitor.

Leo Taylor
18 Ridge Ct W, Apt 21C
West Haven CT 06516

You've got the right idea with respect to customizing and extending monitors. I've done a similar thing in my own machine by writing a monitor program much more capable than MIKBUG. How'd you like to start a 6800 systems programming special interest group? . . . CH

ALTAIR WORD PROCESSING NEEDED

I am interested in using my Altair 8800 to produce clean letters and reports from text entered through a keyboard with editing capabilities. Is there anyone out there who has an Altair compatible software package who can help me?

Also I'd like to inform you that we have formed a Stony Brook Homebrew Computer Club, which is both hardware and software oriented. We have friendly and informal meetings and access to various simulators and cross-assemblers on the school computer. Members have their own systems to demonstrate and discuss (8080 and 6800).

Ludwig Braun
Professor of Engineering
State University of NY at Stony Brook
Stony Brook NY 11794

Text editing is one area where we expect to use our office Altair, among other things. Try writing in 6 months or a year if you haven't found a source by then.

YE OLDE BOARD SWITCHE MANOEUVRE

The following is a simple fix I found for a crashing Altair 8800. The symptom was apparent false jumps when loading and operating 12 K BASIC for a few minutes. These errors wiped out parts of the loaded software, outputting "syntax" errors, garbage or nothing. The fix was to move the processor card to the center of the case (near the fan), away from other boards, and to tape (double back sticky) an aluminum foil (~1 X 2 inch) heat sink (convection cooled) onto the SN74123. No problems have occurred since.

Dr F R Ruckdeschel
Principal Scientist
Xerox Corp
PCDD/P&MS/EDPA
800 Phillips Rd
Bldg 129
Webster NY 14580

WANTED – 6502 USERS

I would like to say that I enjoy your magazine very much, and look forward to it every month. It always seems to have the articles I am looking for, and they are always entertaining.

I am presently bringing up a 6502 on an OSI superboard and am interested in speaking to anyone with a micro, especially a 650x series computer. If anyone has a monitor that they think is really great, or at least perfect, please give me a call or drop me a line. My phone number is (613) 692-3786. Ask for Kevin.

Kevin Szabo
Box 86, Hillcrest Dr
R R 1, Manotick, Ontario
CANADA K0A 2N0

PAGING WITH AN 1802

First of all, thanks for coming up with a computer magazine for the experimenter just when I needed it.

In regards to the editorial "The Address Space Saturation Problem" by Carl Helmers in your November 1976 issue, page 16, I would like to make a suggestion. The RCA Cosmac 1802 microprocessor, which was used in the recent

Continued on page 94

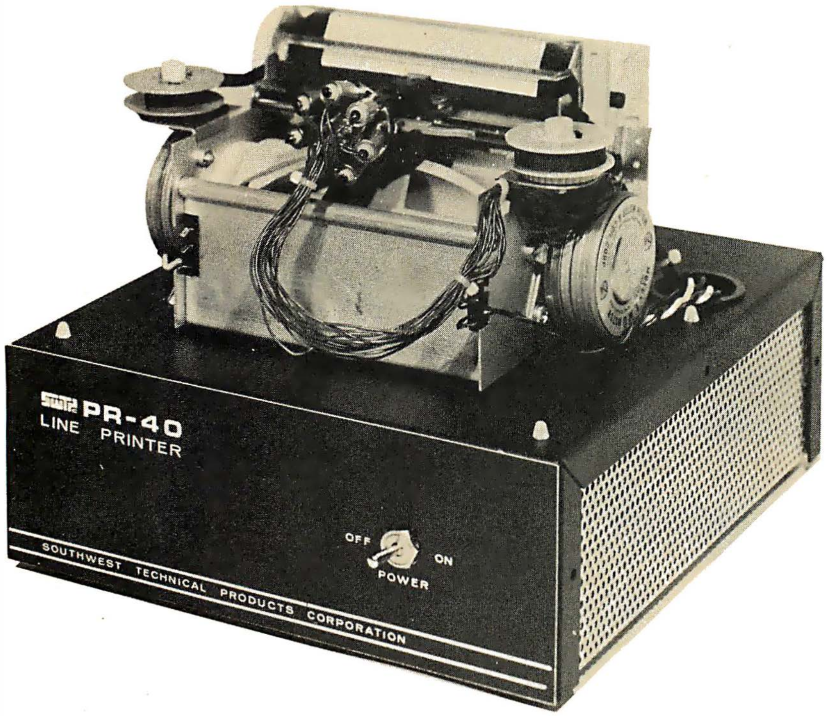


Photo 1: The PR-40 dot matrix printer as assembled from the kit distributed by Southwest Technical Products. The printer is not enclosed in a case but is mounted on a black anodized aluminum chassis with overall dimensions of 9.63 by 10.50 by 8.75 inches (24.45 cm by 26.67 cm by 22.23 cm).

A Review of the SWTPC PR-40 Alphanumeric Printer

Gary Kay
Southwest Technical Products Corp
219 W Rhapsody
San Antonio TX 78216

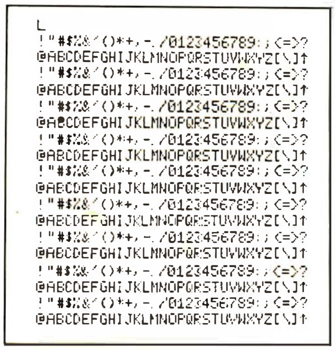
Ever since the microprocessor's introduction, computer hobbyists everywhere have been searching for a low cost alphanumeric printer. One place the search can stop is at the unit presented here: a 5 by 7 dot matrix impact printer. It prints the 64 character upper case ASCII set with 40 characters per line at a rate of 75 lines per minute on standard 3.875 inch (9.843 cm) rolls of adding machine paper, as shown in figure 1. One complete line is printed at a time from an internal 40 character first in first out buffer memory. Printing takes place either on receipt of a carriage return or automatically whenever the line buffer memory is filled.

The printer can accept character data as fast as one character per microsecond (until the buffer is full) or as slow as you wish to send it. The printer's seven parallel data lines are TTL compatible and may be enabled by a single data ready control line or by separate data ready and data accepted handshake control lines. This universal approach makes the printer compatible with all computer and terminal systems having an eight bit parallel interface port; including, of course, the SWTPC 6800 and MITS Altair 8800 computer systems.

The printer mechanism is attached to a black anodized aluminum chassis with front trim panel which houses the circuitry including its own 120 or 240 VAC 50 to 60 Hz power supply circuit shown in figure 2, making the printer's overall dimensions 9.625 by 10.50 by 8.75 inches (24.45 by 26.67 by 22.23 cm).

The Mechanics

The entire design, shown in photo 2, is based on a simple and reliable print mechanism intended originally for point of sale



```
L
!"#$%&'()*+,-./0123456789:;<=>?
@ABCDEFGHIJKLMNOPQRSTUVWXYZ[\]↑
!"#$%&'()*+,-./0123456789:;<=>?
@ABCDEFGHIJKLMNOPQRSTUVWXYZ[\]↑
!"#$%&'()*+,-./0123456789:;<=>?
@ABCDEFGHIJKLMNOPQRSTUVWXYZ[\]↑
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@ABCDEFGHIJKLMNOPQRSTUVWXYZ[\]↑
!"#$%&'()*+,-./0123456789:;<=>?
@ABCDEFGHIJKLMNOPQRSTUVWXYZ[\]↑
```

Figure 1: Example printout demonstrating the type of characters that are generated by the PR-40 dot matrix printer. The printout is the width of readily available 3.875 inch (9.843 cm) adding machine paper. The test program of listing 1 generated this printout.

terminal use. The printed characters are formed by moving the print head horizontally across the paper while selectively energizing solenoid driven print wires on the head which strike an inked ribbon and imprint dots on standard adding machine paper. All seven of these solenoid driven print wires converge at the tip of the print head in a vertical line which is perpendicular to the horizontal direction of movement of the print head. By selectively firing the print wires, 5 dot wide by 7 dot high characters are printed as the print head moves across the paper. A one dot time spacing is left for separation between the printed characters.

This method of printing characters is not new but the method of moving this wire impact print head is unique. Rather than using dual motors, clutches, timing bars and the other hardware usually associated with

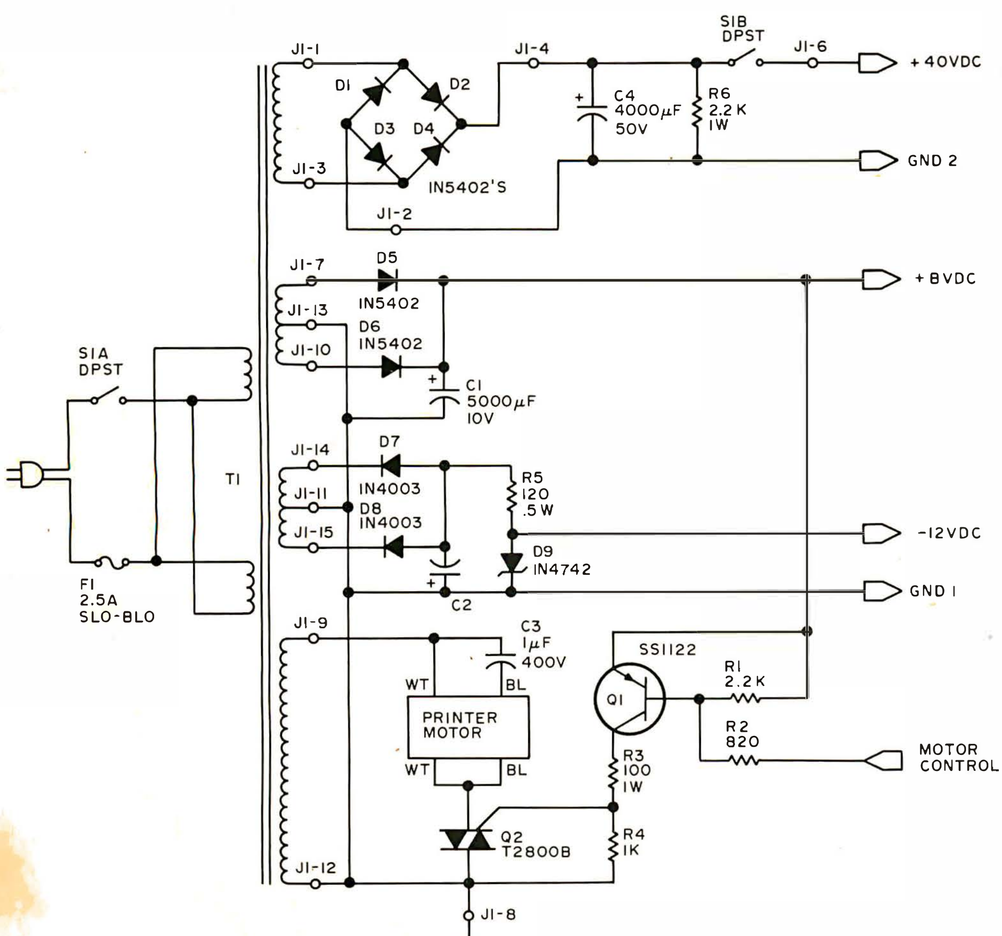


Figure 2: The schematic diagram of the power supply circuit for the PR-40 printer. This power supply can be run on either 120 or 240 VAC depending on whether the primary winding is wired in parallel or series. The power transformer, T1, has a 120, or 240 V primary; 32 V @2 A, 12.5 V @1 A center tapped, 120 V @200 mA center tapped secondaries. As can be seen in the diagram, the printer motor is triac controlled, taking its on and off states from the position of the printer head on the page. All resistors are measured in ohms and are 0.25 W unless otherwise stated.

A Printer Testing Program

The printer diagnostic program of listing 1 has been written to test and debug the SWTPC PR-40 printer when it has been interfaced to the SWTPC 6800 computer system through one of the MP L parallel interface boards. It is assumed that before loading this program, the rest of the system is functioning normally with no problems. The program itself uses 60 words and is loaded within the 128 word programmable memory used by the MIKBUG® operating system on the MP A microprocessor and system board. A program may reside in external programmable memory simultaneously with the diagnostic loaded within the 128 word programmable memory, or the diagnostic may be run with no MP M memory boards installed on the system at all. The diagnostic may be loaded either from tape or instruction by instruction using MIKBUG starting from hexadecimal address A014 through A024 and then from hexadecimal address A048 through A072. The address of the MP L parallel interface board feeding the printer must be set using MIKBUG to load the hexadecimal address of the selected port into hexadecimal memory locations A002 and A003 with the most significant byte going into A002 and the least significant byte going into A003. The starting address locations of the interface ports are given in table 1.

Since the program counter is set when the program is initially loaded, the diagnostic is initiated as described in the "go to user's program" section of Engineering Note 100. Once initiated, the program can be stopped only by depressing the reset button. The program may then be restarted after resetting the program counter to hexadecimal A04A as described in the "display contents of processor registers function" section of Engineering Note 100.

The diagnostic works by sending out an ASCII carriage return, hexadecimal 0D, followed by hexadecimal ASCII characters 21 through 3F followed by another carriage return 0D, followed by hexadecimal ASCII characters 40 through 5E inclusive, repeating itself until stopped with the reset switch.

Each character is output to the printer by first storing the ASCII character's bits 0 through 6 on output lines 00 through 06 of the selected MP L parallel interface port, then bringing the normally high data ready line low via interface output control line C2 for at least 1 μs, then returning the line high again. The data must be held stable on the interface output lines, however, until the printer acknowledges data receipt by bringing its normally high data accepted line momentarily low and then high again. This latter low to high transition signifies that the printer has accepted the character. The MP L control line C1 fed by this line has been programmed to see the low to high data accepted transition and responds by allowing the program to output the next sequential ASCII character.

To set the printer's line width adjustment, you should use MIKBUG to change the data in hexadecimal memory locations A056 and A065 from 0D to 00. This will eliminate the transmitted carriage returns and force the printer to print a full 40 column line. The line width control should then be adjusted for symmetrical margins. The characters will still be printed sequentially but will not be identical from line to line.

Do not operate the printer more than a minute or so while running this diagnostic. Continuous printing of full length lines with no spacing between characters overheats the solenoids on the print mechanism which may decrease its operating life.

If you are using the SWTPC PR-40 printer with the SWTPC 6800 computer system, you may use the OUTCHR subroutine listed from address A014 through A024 in the PRNTST diagnostic within your own program for outputting characters to the printer. The index register must be loaded with the starting address of the MP L parallel interface board feeding the printer. The character to be printed must be loaded into accumulator A and the contents of accumulator B are destroyed during the subroutine.

Never install or remove the interface board when the system is powered up. Doing so is not only hazardous to the equipment, but bypasses the normal power up sequence required by the internal registers within the 6820 integrated circuit in order to guarantee proper operation.■

Note: MIKBUG is a trademark of Motorola Inc.

Listing 1: A debug and test program written for a 6800 type system with MIKBUG. The hexadecimal address of the selected port is loaded into memory locations A002 and A003 which are referred to by PARADR. The program counter is initiated at the beginning of the program. The program sends out a carriage return, hexadecimal ASCII characters 21 through 3F followed by a carriage return, followed by hexadecimal ASCII characters 40 through 5E, and repeated indefinitely.

Address	Op	Operand	Label	Mnemonic	Commentary
A014	A7	00	OUTCHR	STA A 0,X	PARADR:=A;
A016	C6	37		LDA B #37	} PARADR+1:=37;
A018	E7	01		STA B 1,X	} [data ready port]
A01A	C6	3F		LDA B #3F	} PARADR+1:=3F;
A01C	E7	01		STA B 1,X	} [data ready port]
A01E	6D	01	LOOP3	TST 1,X	check if data accepted signal received;
A020	2A	FC		BPL LOOP3	if signal not present go to LOOP3;
A022	E6	00		LDA B 0,X	else B:= PARADR
A024	39			RTS	return;
A048	A0			MSB	} [program counter]
A049	4A			LSB	} [program counter]
A04A	FE	A0 02	START	LDX PARADR	X:= PARADR; [IO port address]
A04D	C6	FF		LDA B #FF	} PARADR:=FF;
A04F	E7	00		STA B 0,X	} PARADR:=FF;
A051	C6	3F		LDA B #3F	} PARADR+1:=3F;
A053	E7	01		STA B 1,X	} PARADR+1:=3F;
A055	86	0D	FSTLIN	LDA A #0D	} output carriage return;
A057	8D	BB		BSR OUTCHR	} output carriage return;
A059	86	20		LDA A #20	A:=20;
A05B	4C		LOOP1	INC A	A:=A+1;
A05C	81	40		CMP A #40	compare A to 40;
A05E	27	04		BEQ NXTLIN	if A=40 go to NXTLIN;
A060	8D	B2		BSR OUTCHR	go to OUTCHR;
A062	20	F7		BRA LOOP1	go to LOOP1;
A064	86	0D	NXTLIN	LDA A #0D	} output carriage return;
A066	8D	AC		BSR OUTCHR	} output carriage return;
A068	86	3F		LDA A #3F	A:=3F;
A06A	4C		LOOP2	INC A	A:=A+1;
A06B	81	60		CMP A #60	compare A to 60;
A06D	27	E6		BEQ FSTLIN	if A=60 go to FSTLIN;
A06F	8D	A3		BSR OUTCHR	go to OUTCHR;
A071	20	F7		BRA LOOP2	go to LOOP2;

Table 1: Hexadecimal starting addresses of the parallel IO port interfaces used by MIKBUG.

Port	Address in Hexadecimal
IO 0	8000
IO 1	8004 (reserved for control interface)
IO 2	8008
IO 3	800C
IO 4	8010
IO 5	8014
IO 6	8018
IO 7	801C

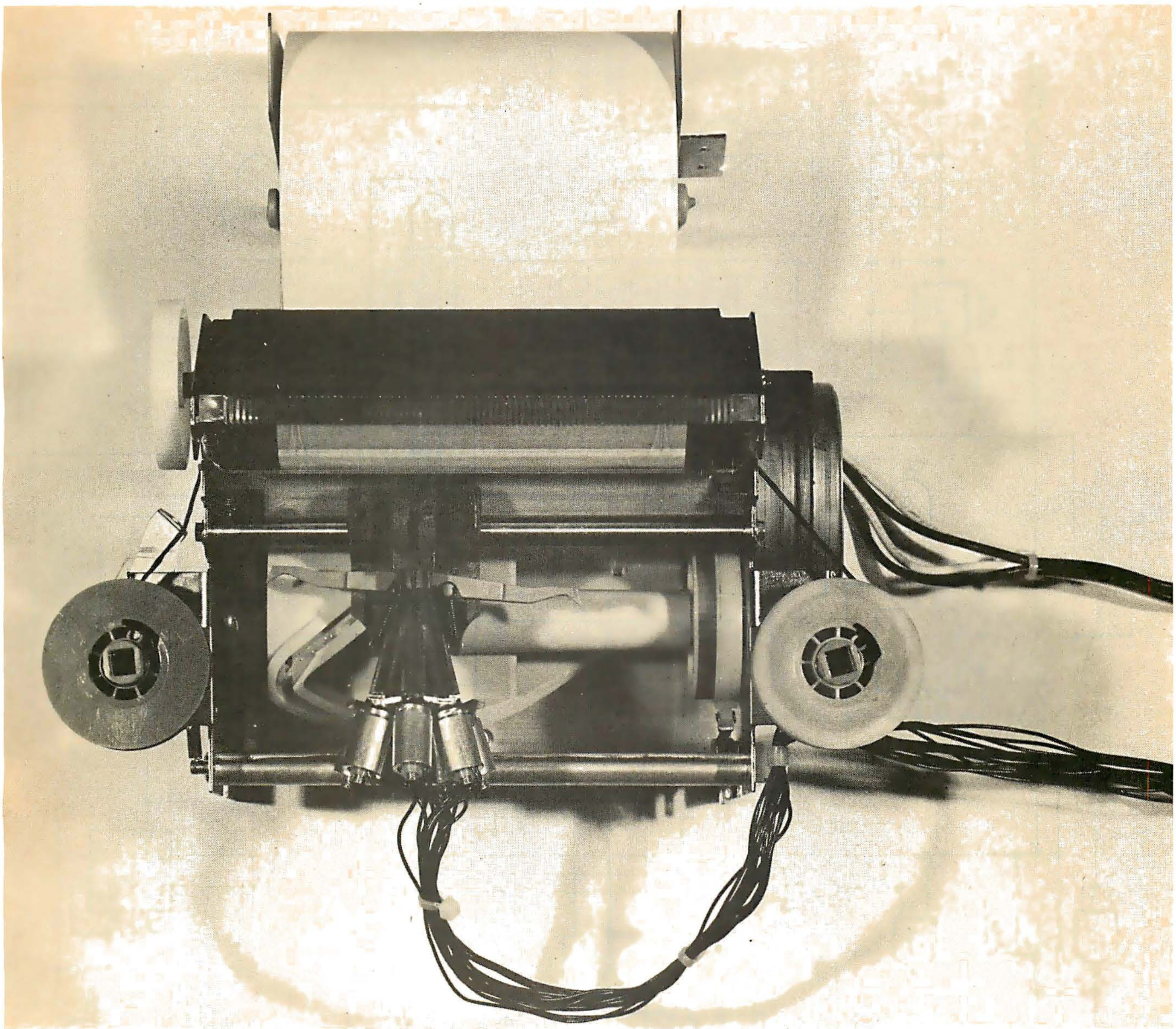


Photo 2: This photograph displays the mechanical parts of the PR-40 printer. The seven solenoids can be seen to converge in a line at the print head. The positioning mechanism for the printing head is seen as the spiral groove under the head mechanism.

this type of print head, this printer rotates a long cylinder just beneath the print head. The length of the cylinder itself is a little longer than the head's printing width on the paper. The cylinder has a uniform cyclic zigzag track formed on its outer circumference, running from the left side of the cylinder to the right side and then back to the left again. A small projection on the bottom of the print head rides in this track so that as the cylinder rotates, the print head moves back and forth from left to right. This technique moves the print head across the paper at a constant velocity except for the extreme ends, where nothing is being printed. This approach greatly simplifies the electronics needed to drive the printer since no head positioning circuitry is necessary. The cylinder itself is turned by an AC motor on the lower right hand side of the print mechanism. (See photo 1.) A small ribbed nylon belt interconnecting the two rides on gear teeth of both the motor and cylinder. Also attached to the right side of the cylinder is a cam that actuates a roller arm microswitch riding on the cam. This is how the printer's electronic circuitry senses the start of line position of the print head. On the left side of the cylinder is an eccentric driven pawl arm that advances the paper one line for each revolution of the cylinder which is the same as one cycle of the print head.

Let's go through a single cycle of operation of a printed line where we will first assume the head is in rest position just left of center. When a line print command is initiated by the control circuitry, the motor

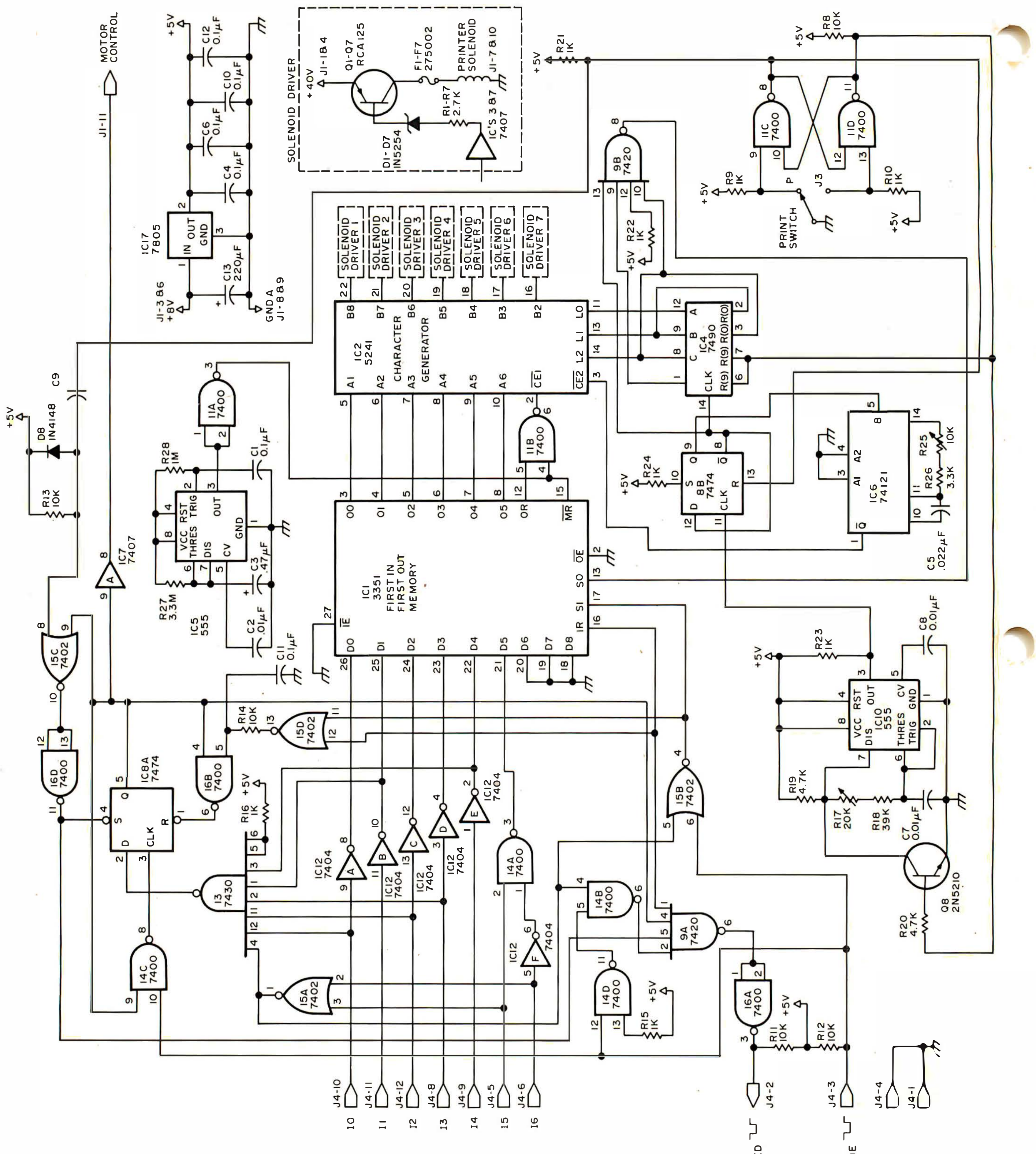


Figure 3: Schematic diagram for the PR-40 impact printer. NAND gate IC14A converts the lower case ASCII characters to upper case ASCII characters. The printer outputs a line of data at a time. The data is output when a carriage return is received or 40 characters have been entered into the memory buffer. All ASCII control characters, except carriage return, are ignored since they are not printed anyway. All resistors in this circuit are measured in ohms and are 0.25 W.

starts and the head begins to move from the center position toward the far left side of the printer where the head reverses direction. This nonprint dead zone gives the motor, cylinder and print head time to attain full speed. As the head begins its movement from left to right, the cam actuated microswitch opens telling the electronic circuitry to start sending solenoid driving pulses for the character. Somewhere before the print head reaches the far right hand edge of the paper, the solenoid pulses will cease while the head continues to move. When the head reaches the right end of its travel, it will mechanically reverse direction and begin to move back toward the center of the printer. During this return movement, the pawl arm will rotate the platen one line for the line feed. The motor is then turned off just to the left of center where it started originally. With our controller for this mechanism, character data is not accepted by the printer's circuitry during an actual print cycle; however, feeding continual print data from a computer to the printer may take place so fast that the print motor may never appear to stop between repeatedly printed lines although it actually does.

The operation of the printing ribbon used on the unit is also amazingly simple. A ratchet technique not only advances the ribbon incrementally for each cycle of the print head but automatically reverses it when it reaches the end of one of the two spools.

The Electronics

The electronic circuitry designed to drive the print mechanism can vary from nothing but motor and solenoid drivers constantly serviced by the microprocessor to a fully self-contained hardware control unit with memory needing only 7 bit parallel ASCII data and a data ready strobe control line from the computer. The printer electronics of the PR-40 fits into the latter category. The PR-40's controller has its own 40 character first in first out memory allowing the computer to send character data at whatever speed it wishes. The entire line is printed upon receipt of a carriage return, hexadecimal 0D, or automatically whenever the 40 character line buffer has been filled. All control characters with the exception of a carriage return are ignored by the printer. They are not stored in the buffer line memory since they cannot be printed anyway. Repeated line feeds are initiated by sending repeated carriage return control commands. Since the controller generates upper case ASCII characters only, all lower

Table 2: Power pins for the circuit of figure 3.

Number	Device	+5 V	GND	−5 V	−12 V
IC1	3351	26		28	27
IC2	5241	12			23,23
IC3	7407	14	7		
IC4	7490	5	10		
IC5	555	8	1		
IC6	74121	14	7		
IC7	7407	14	7		
IC8	7474	14	7		
IC9	7420	14	7		
IC10	555	14	8		
IC11	7400	14	7		
IC12	7404	14	7		
IC13	7430	14	7		
IC14	7400	14	7		
IC15	7402	14	7		
IC16	7400	14	7		
IC17	7805		3		
IC18	7474	14	7		

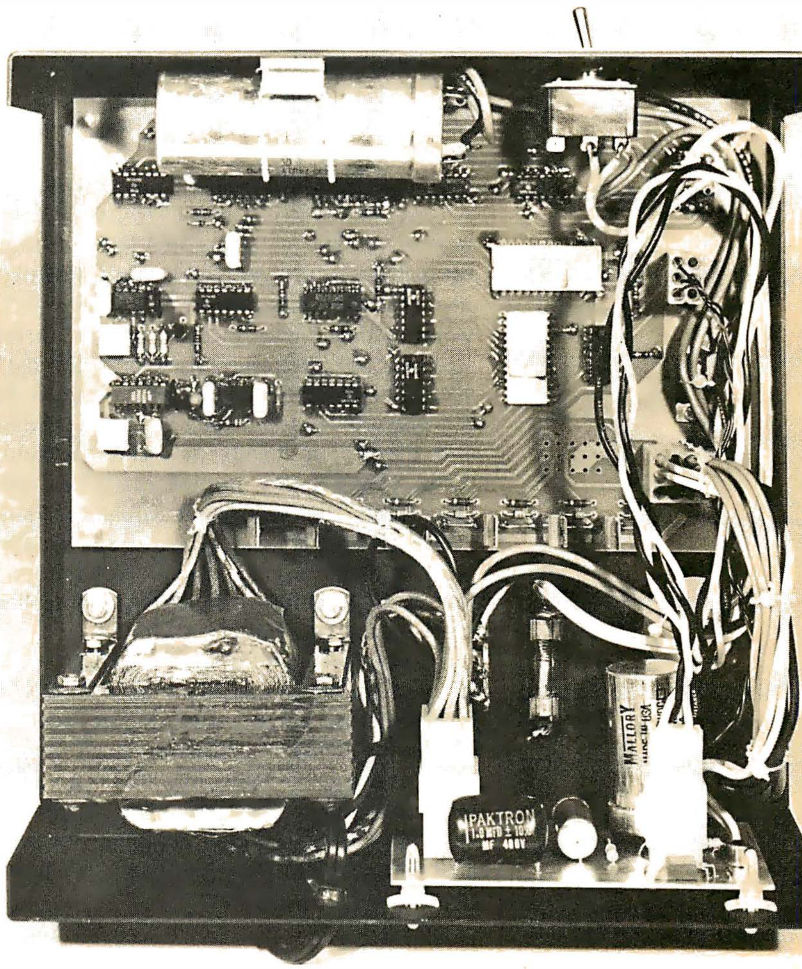


Photo 3: A view from the bottom of the PR-40 impact printer displaying the electronic circuitry of the system. The circuit board at the top left of the picture is the circuit for the power supply as described in figure 2. The circuit at the bottom of the picture is the electronic assembly for the print head driver. The large chip at the bottom left of the picture is the first in first out memory chip. The IC chip directly above it is the read only memory character generator.

case characters sent to the controller are transposed to their upper case equivalent before printing. The printer's line buffer memory is automatically cleared by a hardware power up reset circuit when printer power is first applied. The printer's triac controlled motor is powered by a 120 VAC secondary on the power supply's power transformer, as shown in figure 2. This not only provides power line isolation but allows the entire unit to be run on either 120 VAC or European 240 VAC power systems since the power transformer has two primary windings which may be either parallel or series connected.

The seven ASCII parallel data input lines, data ready, and data accepted control lines are all TTL compatible. The inputs represent a maximum of two standard TTL loads while the data accepted output will drive ten standard TTL loads. Data is presented to the printer by storing the selected ASCII data on the seven data input lines and strobing the normally high, logic 1, data ready input line low. This line should go low, logic 0, for at least 1 μs and when it does the normally high data accepted will also go low. The character is not actually loaded until the data ready input is returned to its normally high state. The data accepted line will then normally return high as well, indicating that the character has been loaded. However, when loading the 40th character on a print line or a carriage return command, this data accepted line will not return high until all the previously stored data has been printed and the printer memory is ready for more data. The PR-40's printer controller will ignore all data sent to it while the data accepted line is low. So you will usually want to make sure the data accepted output line is high before sending the controller more data to be printed.

If you are careful not to output data faster than one character per μs and allow a minimum one second delay before sending data after sending a carriage return or the 40th character of each line then you may avoid using the data accepted line altogether. However, using the data accepted line will give your system the fastest possible print speed.

How It Works

All ASCII character data is presented to the first in first out memory, IC1, through hex inverter and buffer, IC12. NAND gate IC14A makes any necessary conversions from lower to upper case characters. 8 input NAND gate IC13 monitors the incoming ASCII data in search of a carriage return, hexadecimal 0D, control command. If it decodes a carriage return it will prepare normally high control flip flop IC8A to go low on the falling edge of the data ready control signal. NOR gate IC15A decodes all control characters and along with IC15B inhibits any control characters from being loaded into the buffer memory. NAND gate IC9A is responsible for generating the data accepted control output whenever data has been accepted by the buffer memory or acknowledged by the control character decode logic. It also inhibits the data accepted output while the printer is in the process of printing a line.

Control flip flop IC8A's Q output is high when the printer is in the idle state. A buffer memory full signal decoded by NOR gate IC15D or a decoded carriage return command by IC13 resets this flip flop low which turns the printer's motor on through transistors Q1 and Q2 located on the power supply board which starts a line print sequence.

When the print head advances to the start of line position, the roller arm microswitch changes states which flips RS latch NAND gate IC11D low which allows free running oscillator, IC10, to feed divide by 2 flip flop, IC8B. This divide by 2 feeds both the dot counter, IC4, and solenoid timer, IC6. This solenoid timer is used to set the on time of the printer's solenoids. If set too long, the solenoids will overheat; if set too short, the printed lines will be too light. An on time duration of 400 μs is the best compromise setting. Decode counter IC4 has its B and C outputs tied back to its zero reset inputs forcing it to become a modulo 6 counter. As the counter progresses from 0 to 4 inclusive, the selected character lines are decoded by the read only memory, IC2, using the ASCII data fed to it by the buffer memory, IC1, and fed onto the solenoids through buffers IC3 and IC7 and Darlington drivers Q1 and Q7. Counter state 5 is decoded by the read only memory as a blank for the one dot space necessary to separate the printed characters. In the latter phase of the five count the memory buffer is shifted, the counter resets, and the sequence repeats. When the memory buffer finally empties, the read only memory is disabled and blanks the output for the rest of the print cycle. When the still moving print head reaches its normal rest position, the roller arm microswitch again changes states. This time RS latch NAND gate IC11C flips low, setting control flip flop, IC8A, back to normally high state. Timer IC5 is a power up clear circuit which empties the first in first out buffer memory and helps prevent random firing of the print solenoids during power up.■

The PR-40 alphanumeric printer is manufactured by Southwest Technical Products Corp, 219 W Rhapsody, San Antonio TX 78216. It is sold in kit form only. The kit number is #PR-40 for $250 post paid in the United States. The kit includes the print mechanism, chassis, circuit boards, components, power supply, assembly instructions, one ribbon and one roll of paper.

Cassette Transports for the "Roll Your Own" Hobbyist

William H Freeman
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Glenview IL 60025

Use of the Phillips Compact Cassette as a storage medium has been well established. Articles in BYTE and other publications have made the audio cassette just about the only storage device for the computer hobbyist. However, not enough attention has been given to the machine in which the cassette is operated. From various articles the usual transport mechanism is usually referred to as a cheapie or $30 cassette recorder. The usual control is a relay used to turn on the entire device. I regard this method as less than satisfactory and suggest that there are better ways.

When the low cost cassette machine is turned on or off with a relay, two difficulties are immediately apparent. First the pinch roller is always engaged, which can cause a dent in the roller if left too long in this position. The dent will cause serious wows in the tape speed. Second, the startup time will be excessively long. This leads to the conclusion that the entire tape transport mechanism should be controlled by the computer. All of the transport functions, play, stop, rewind and fast forward, should be available on command by the computer.

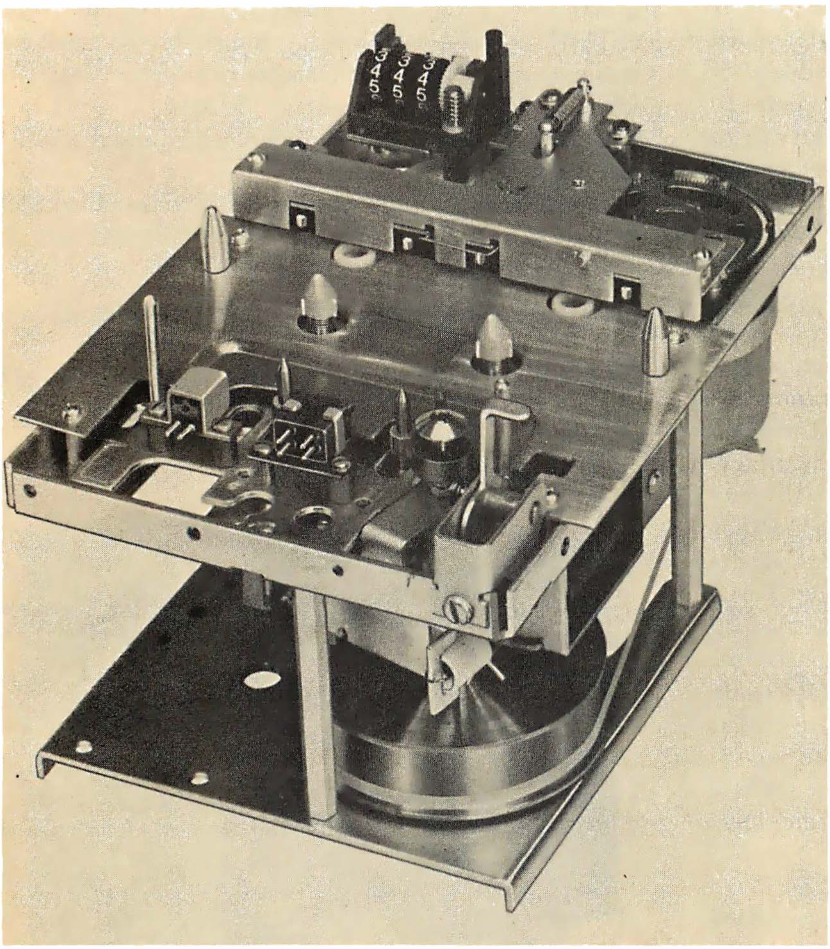


Photo 1: The Amilon A9 cassette transport. It is similar to the A7 transport varying only in a different head mount and the lack of an index counter on the A7 model.

Audio cassette transports which will meet the requirement of being controlled by logic signals are available and can be purchased by the computer hobbyist. These transports have usually been available to the original equipment manufacturer (OEM), but the various manufacturers have indicated that they will sell to individuals or groups. One of the manufacturers of cassette transports, the Economy Company, has been actively promoting use of their deck for data storage, but more about it later.

To the best of my knowledge, there are only four companies in the US making and selling "bare bones" cassette transports. One of these companies, TELEX Communications, only has a manually operated transport, which cannot be controlled by a computer and is of no real interest to the computer hobbyist, even though it is a well constructed, rugged unit. The three remaining companies, Amilon Corporation, the Economy Company and the Mincom Division (Wollensak) of 3M, all have transports which are amenable to logic control since they have solenoids doing the work.

The Amilon Corp has two cassette transport models which might be used by the computer hobbyist. One model, the A9, is primarily an audio unit with mono or stereo heads for playing or recording usual audio type information. The other model, the A7, has characteristics slanted to the data storage business. The two machines are very much alike structurally, being built on the same basic frame. They are the same in size and weight, and require the same electrical inputs. Table 1 lists the performance details and shows the similarity of the two transports.

Optical end of tape sensing is available as

an option. The lamp used is a 5 V, 100,000 hour rated lamp. Four kinds of cassette sensing options are available using up to four micro switches to sense the cassette in place, record tab A and tab B and side A. Side A sensing is detecting the off center slot on the back edge of the cassette which is present in a computer cassette.

Both the capstan and reel motors are AC induction motors which means long, reliable operation with no brush noise problems. The capstan motor is a synchronous one and is used to drive only the capstan, insuring accurate speed. The other motor is used to drive either the takeup spindle in the play, record, and fast forward modes or to drive the supply spindle in the rewind mode. Amilon claims this is the reason for the excellent wow and flutter performance as there is no motor acting as a drag when in the play or record mode. The mechanical structure is solid and stiff, assuring continued alignment of all parts. In particular, the pinch roller is mechanically isolated from the heads and is mounted on self-aligning instrument ball bearings to give even pressure on the capstan and minimizing any skew of the roller.

I was greatly impressed with the quality and attention to detail in this machine when the A9 model was demonstrated. Amilon Corp is also involved with digital cassette transports and some of their thinking has rubbed off on the audio cassette transport's design, to the audio transport's advantage. Photo 1 shows the Model A9 transport. The A7 model is almost identical, differing only in the head mount and its lack of an index counter.

You want to know what it costs? OK! Prices for the A7 transport, the data unit, start at $210 for one ($113.51 each in quantities of 100) which includes a precision head mount and a two track read and write head. End of tape sensing and cassette sensing switches are extra. Prices for the A9 transport start at $164.75 for one ($87.79 each in quantities of 100) which includes standard head mounts, stereo erase, and record and play heads. End of tape and cassette sensing switches are extra.

Next on the list of transports, alphabetically, is the Economy Company with its Phi-Deck. The Economy Co is a school book publisher for elementary education. Some years ago they added educational cassette

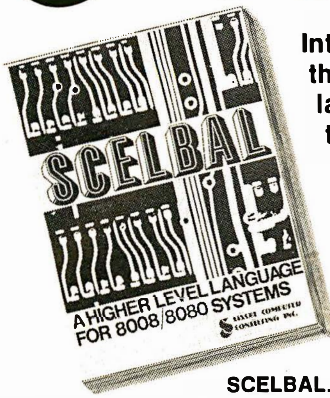
	A7	A9
Play or Record Speed	1.875 to 10.0 in per sec† 4.763 to 25.4 cm per sec	1.875 or 3.75 in per sec* 4.763 or 9.53 cm per sec
Speed Accuracy	±2% at any speed	±1% (±0.3% available) at any speed
Wow and Flutter	not stated	<0.1% NAB weighted
Reel Controlled Search Speed	50 in per sec average 127 cm per sec average	not available
Fast Wind or Rewind	not available	70 sec for C60 cassette
Start Time	<40 ms	<300 ms
with speedup circuit	<25 ms	
Stop Time	<60 ms	<50 ms
Sensor Switches	SPDT	SPDT
Operating Humidity	0 to 95% noncondensing	
Operating Temperature	+5° to +50°C	
Storage Temperature	–20° to +70°C	
Size	5.16 by 7.00 by 4.61 in 13.10 by 17.78 by 11.71 cm	
Weight	5.00 pounds 2.27 kilograms	
Capstan motor (synchronous)	117 V ± 10%, 50 or 60 Hz, 11 W	
Reel motor (fast mode)	24 V ± 10%, 50 or 60 Hz, 13 W	
Reel motor (play mode)	18 V ± 10%, 50 or 60 Hz, 8 W	
Solenoids	24 VDC, ±5%, 600 mA	

†Ten different speeds available: 1.875, 2.0, 3.0, 4.0, 5.0, 6.0, 7.0, 8.0, 9.0, 10.0 in per sec
4.763, 5.1, 7.6, 10.2, 12.7, 15.2, 17.8, 20.3, 22.86, 25.4 cm per sec

***Dual speed pulley available.**

Table 1: Comparison of the A7 and A9 cassette transports manufactured by Amilon comparing speed, accuracy, and power requirements of the two units.

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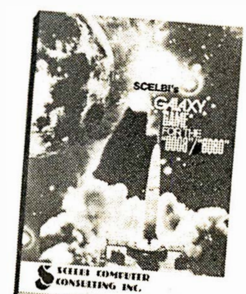
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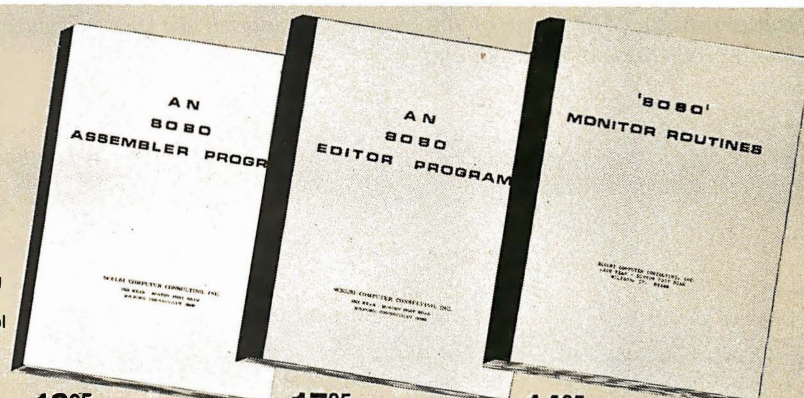
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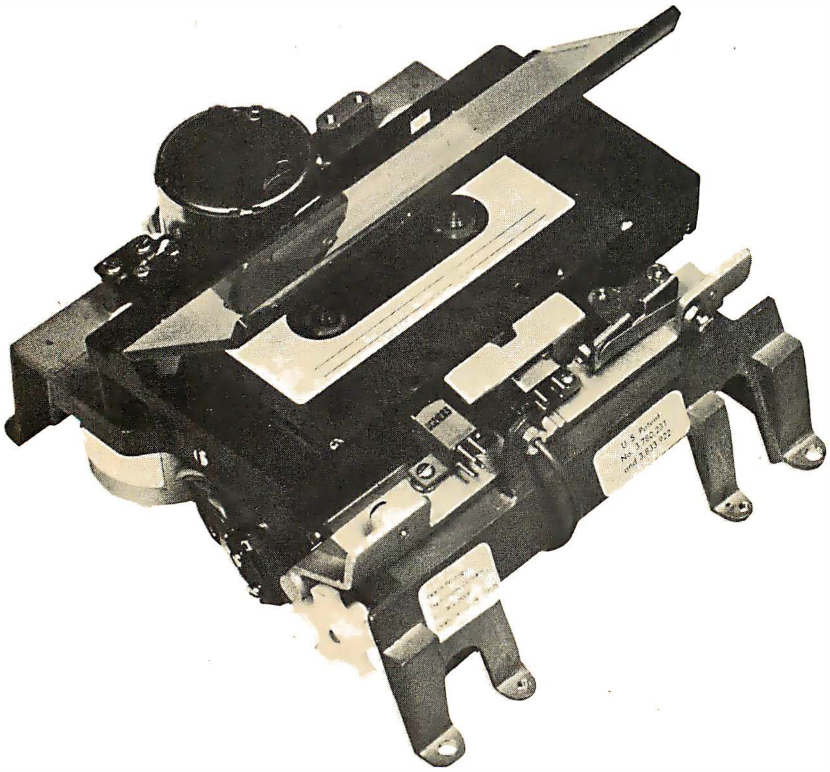


Photo 2: The Phi-Deck Super Deck model manufactured by the Economy Company. This model allows varying tape speeds by varying the voltage to the capstan motor. The frame of the cassette transport is die cast, reducing alignment problems and making it quite rigid.

publishing to their product line. This produced demand for an audio unit to play the cassettes, with Phi-Deck the result. Over a year ago I saw the Phi-Deck demonstrated. Since that time the number of Phi-Deck models has increased to three; the advanced model is shown in photo 2. In addition to the transports themselves, the Economy Co is offering control boards to do all the tricky functions on command. The three models are referred to as fixed speed, variable speed, and Super Deck; their performance is tabulated in table 2. At least one personal computing manufacturer (Digital Group) is now offering Phi-Deck as part of a system product at quite reasonable prices.

As is usually the case, the performance figures in table 2 do not tell the whole story. All three transports have four DC motors. One motor drives just the capstan, the speed being maintained by a voltage regulator supplying current to the capstan drive motor. Another motor is used to drive the supply spindle. Still another is used to drive the takeup spindle. And the fourth motor actuates the yoke on which are mounted the heads and the pinch roller by means of a Geneva movement. (A Geneva movement translates rotary motion into linear motion. One revolution of the motor pulls the heads and pinch roller into position and another revolution moves them out of position. The motor always turns in the same direction!)

These DC motors are ideal for direct control with transistors since they run off

Table 2: Comparison of the three cassette transports manufactured by the Economy Company giving electrical comparisons and the physical dimensions and weight of the transports.

	Fixed	Variable	Super
Speeds	1.88 in per sec standard 2.00, 3.75, 4.00, 5.00, 6.00 in per sec optional 4.77 cm per sec standard 5.08, 9.53, 10.16, 12.70, 15.24 cm per sec optional	0.40 to 20.00 in per sec 1.02 to 50.80 cm per sec	1.00 to 10.00 in per sec standard 0.40 to 3.00, 0.60 to 5.50, 0.85 to 8.50 in per sec optional 2.54 to 25.40 cm per sec standard 1.02 to 7.62, 1.52 to 13.97, 2.16 to 21.59 cm per sec optional
Wow and Flutter	<0.25% at 1.88 in per sec 4.77 cm per sec	<0.25% at 1.88 in per sec 4.77 cm per sec	not stated
Bit to Bit Jitter	not stated	±2%	±2%
Speed Accuracy	not stated	±3%	±3%
Start Time	<100 ms	<100 ms	<100 ms
Stop Time	<100 ms	<100 ms	<100 ms
Forward and Rewind Time	<30 sec for C60 cassette	<30 sec for C60 cassette	<30 sec for C60 cassette
Power Required	+12 VDC at 900 mA	+12 VDC at 900 mA	+18 VDC, –18 VDC, +11 VDC, +7 VDC, +5 VDC
Size	2.60 by 5.40 by 6.30 in 6.60 by 13.72 by 16.00 cm	2.60 by 5.40 by 6.30 in 6.60 by 13.72 by 16.00 cm	3.00 by 5.50 by 6.20 in 7.62 by 13.97 by 15.75 cm
Weight	2.20 pounds 1.00 kilograms	2.20 pounds 1.00 kilograms	2.80 pounds 1.27 kilograms

12 V. A transistor in series with the motor acts as a switch controlled directly from the logic circuits. Very straightforward and simple. The logic and control circuits, which can be purchased or built, can do a lot of elegant performing on the part of the transport. In connection with end of tape and beginning of tape sensing options, one can cause the cassette to play to the end, then rewind to the beginning, stop or start playing all over again. By controlling the regulator supplying the capstan motor, different speeds of playing can be obtained. Cassette in place and record tab sensing are also options that are available. With the variable speed model, a different pulley is used for each speed range. The Super Deck model covers its entire speed range with only one pulley.

Of the three models, the one I recommend is the Super Deck as shown in photo 2. It has a diecast frame, making it quite rigid, reducing alignment maintenance problems. The other two models, the fixed speed and the variable speed, have a sheet metal frame that is somewhat flimsy and leaves something to be desired in ruggedness. Literature supplied by the Economy Co suggests that the Super Deck model was designed with data applications in mind, and as such, would be more attractive to the computer hobbyist.

The price of the fixed speed Phi-Deck, including a stereo head, is listed at $94.50 for one. The variable speed model, with all options, lists for $99.50, with either a two halftrack digital head or a regular audio stereo head. The Super Deck, with all control and sensing options, lists for $169 for just one at the time this was written. Electronic control board, remote control boxes and power supplies are also available.

Because of my past experience with maintenance problems, I have a prejudice against the use of DC motors. However, from data supplied by the Economy Co, it appears that they have made a very strong effort to improve the performance of their DC motors. Their data indicates that a mean time before failure of 5000 hours is a reasonable value. This would mean 2.5 years of operating time, assuming 40 hours a week for 50 weeks a year.

I have two objections to DC motors. First is the fact that the motors have brushes and commutators which wear, the brushes principally, and need to be replaced at intervals. In the case of the small motors being considered, many have no provision for replacing the brushes, so one must replace the whole motor. The second objection is that the brushes can cause noise in the associated circuitry, requiring additional parts to suppress it. AC induction motors have no brushes, hence no noise or wear problems. With oilite sleeve bearings they run quietly for a long time.

The last transport models to be described are made by the Mincom Division of the 3M Company. There are three versions, very much alike: Model 9575, Model 9576 and Model 9577. Model 9575 is a manually controlled mechanism and is of no interest to us. Models 9576 and 9577 are solenoid controlled mechanisms which are what we want. All models have the same basic drive

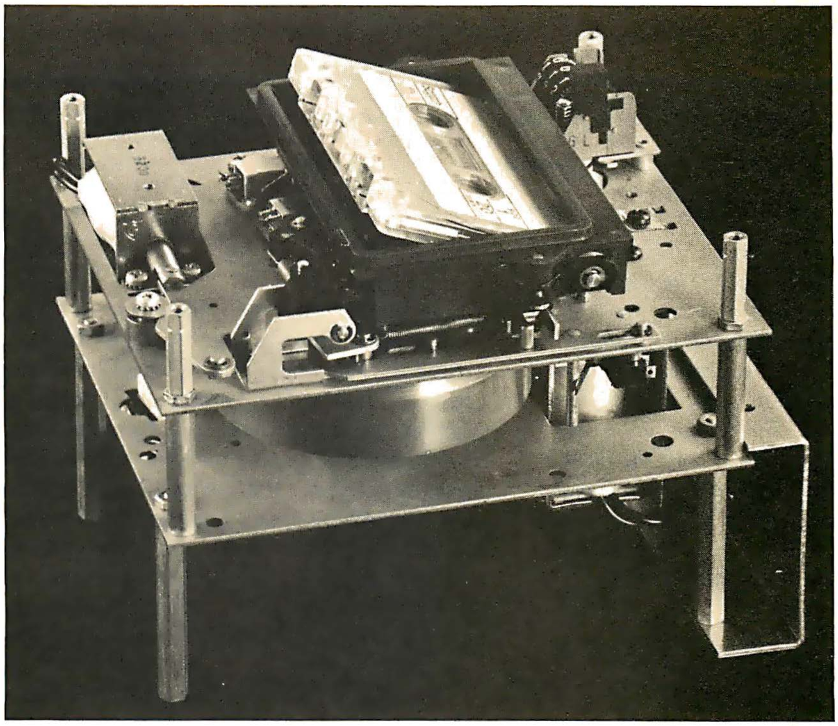


Photo 3: Wollensak Model 9576 and 9577 cassette transports. The two transports are identical, except the 9577 has an optical end of tape sensing unit. The basic construction consists of two heavy metal plates separated by standoffs to form the frame. A flat panel supplied by the user is put on the top of the transport to protect the inner mechanisms.

		Model 9576 and 9577
Play and Record Speed		1.875 in per sec 4.763 cm per sec
Speed Accuracy		±2%
Wow and Flutter		<0.25%
Rewind and Fast Forward Times		45 sec for C60 cassette
Solenoids		24 VDC 72 ohms
Light Source	(Model 9577)	subminiature lamp 5.0 VDC @ 0.075 A
Sensor	(Model 9577)	2N5778 Photodarlington
Size		5.63 by 6.75 by 4.78 in 14.29 by 17.15 by 12.14 cm
Motor Power		117 V, 50 or 60 Hz, 10 W

Table 3: Performance characteristics of the cassette transports manufactured by Wollensak. The two models are the same except that the 9577 has an optical end of tape sensing unit that the 9576 does not have.

	Price	Performance	Mean Time Before Failure
AMILON	high	excellent	very good
PHI-DECK	medium	very good	very good
WOLLENSAK	medium	very good	excellent

Table 4: The author's comparison of the best tape transports manufactured by Amilon, Economy Company, and Wollensak. The ratings are in relation to how well the objectives of low price, high performance, and a long mean time before failure, are achieved.

arrangement. An AC induction motor, shaded pole, drives a large flywheel through a rubber tired idler. The flywheel is on the capstan shaft. The supply and takeup spindles are driven from the flywheel with rubber tired idlers. No belts are used in the drive mechanism. There is one belt but it is used to run the index counter. In the two models of interest, three solenoids control the operating functions. One solenoid is pulled up for play or record; another is pulled up for fast forward; and a third for rewind.

The Model 9576 and Model 9577 are identical in all respects except that the Model 9577 has an optical sensing circuit included. This optical sensing consists of a small 5 V lamp and a phototransistor. This will provide end of tape and beginning of tape sensing. Table 3 lists the performance of both models.

Photo 3 shows the basic construction of the Wollensak transport, consisting of two heavy plates separated by standoffs forming the frame. The user must supply some kind of flat panel with cutouts for the cassette tray, the eject lever and the index counter. Four screws will attach the unit to this panel. This transport, like its big brother units made by Wollensak, is well built and should have a long service life with a minimum of maintenance. My experience with the full size Wollensak cassette units is that they run, and run, and run.

The latest prices available to me are $79.50 for Model 9576 and $85.75 for Model 9577 in quantities of 1-9. In 100 lot quantities prices are $65 and $71.25, respectively. Heads for the transport are extra.

How should these three cassette transports be evaluated? We can use three criteria: price, performance and reliability. Price is easy, just look at the figures. Performance and reliability are not so easy to establish because each potential user will assign different values to the various details of performance depending on the end objective and his or her bias. My bias has already been stated. My evaluations are given in table 4.

Some explanation may be necessary. Amilon is rated excellent in performance because of its very low wow and flutter figure and its tight speed control with a synchronous motor. Wollensak is rated excellent in the mean time before failure column because of my past experience with Wollensak cassette units covering more than six years of usage in the school environment.

If I had an overflowing purse, I would buy the Amilon unit because of its excellent performance. Price is, however, a very demanding factor, so the Wollensak is my choice as the best buy. The Phi-Deck comes in very close in this decision. It is a certainty that not all readers will agree with this evaluation, which is certainly your privilege. The individual who is putting out the green stuff is entitled to make his or her own choice based on what is felt to be important. As they say, "That's what makes a horse race."

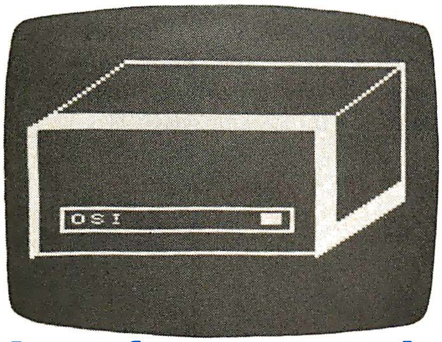
Where can you get one of these cassette transports? In alphabetical order: for an Amilon deck write to Leonard Rosenblatt, Amilon Corp, 49-12 30th Av, Woodside NY 11377; for a Phi-Deck you can find the address in ads in BYTE, but here it is anyway — The Economy Co, Triple I Division, 1901 N Walnut, Oklahoma City OK 73105; and for the Wollensak deck, write to Scott Goff, Sales Manager, Wollensak OEM Products, Mincom Division, 3M Co, 3M Center, St Paul MN 55101.

As a kind of post script to this article, I have included a few words of wisdom about using cassette transports, or any tape machine. *Preventive maintenance* will keep your cassette transport running without problems. Regularly do the following:

1. Clean the capstan, pinch roller, heads and guides after every 10 hours of operation. Use a good fluorocarbon, low toxicity head cleaner; one that will not attack rubber or plastic parts.
2. Keep all parts as dust free as possible. Use a dust cover over the transport when not in use.
3. Lubricate as often as the manufacturer specifies. Do not overlubricate; be sparing with the oil.
4. Demagnetize the heads, capstan and guides with a good head demagnetizer after every 10 hours of operation.

Overall performance will be considerably affected by the quality of the cassette used. Use a good to high quality cassette. Cheap cassettes will have poor tape quality and, even worse, poor mechanical performance which will adversely affect the tape speed. You will find that with the better to best tapes, you get better recordings with better frequency response and all around better performance.■

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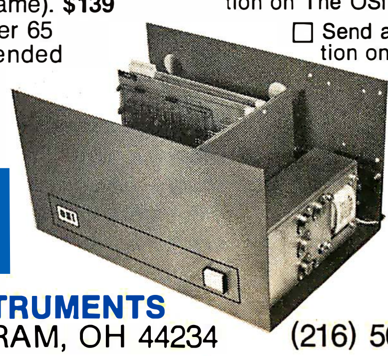
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Continued from page 10

at the servo and in the displays used to monitor the position count.

The program is quite simple: It generates a positive going pulse on the bit 0 line of the PIA output port, a pulse which lasts from 1 ms in length to 1 + 0.012 n ms where n is an 8 bit number which is incremented once each time around the outer loop of the program. The 0.012 ms factor is based on the processor's clock at the time of the test, 500 kHz, and the 6 state loop at addresses 201F and 2020 which times the width of the variable portion of the pulse. With the servo illustrated in photo 1, the wiring used was as

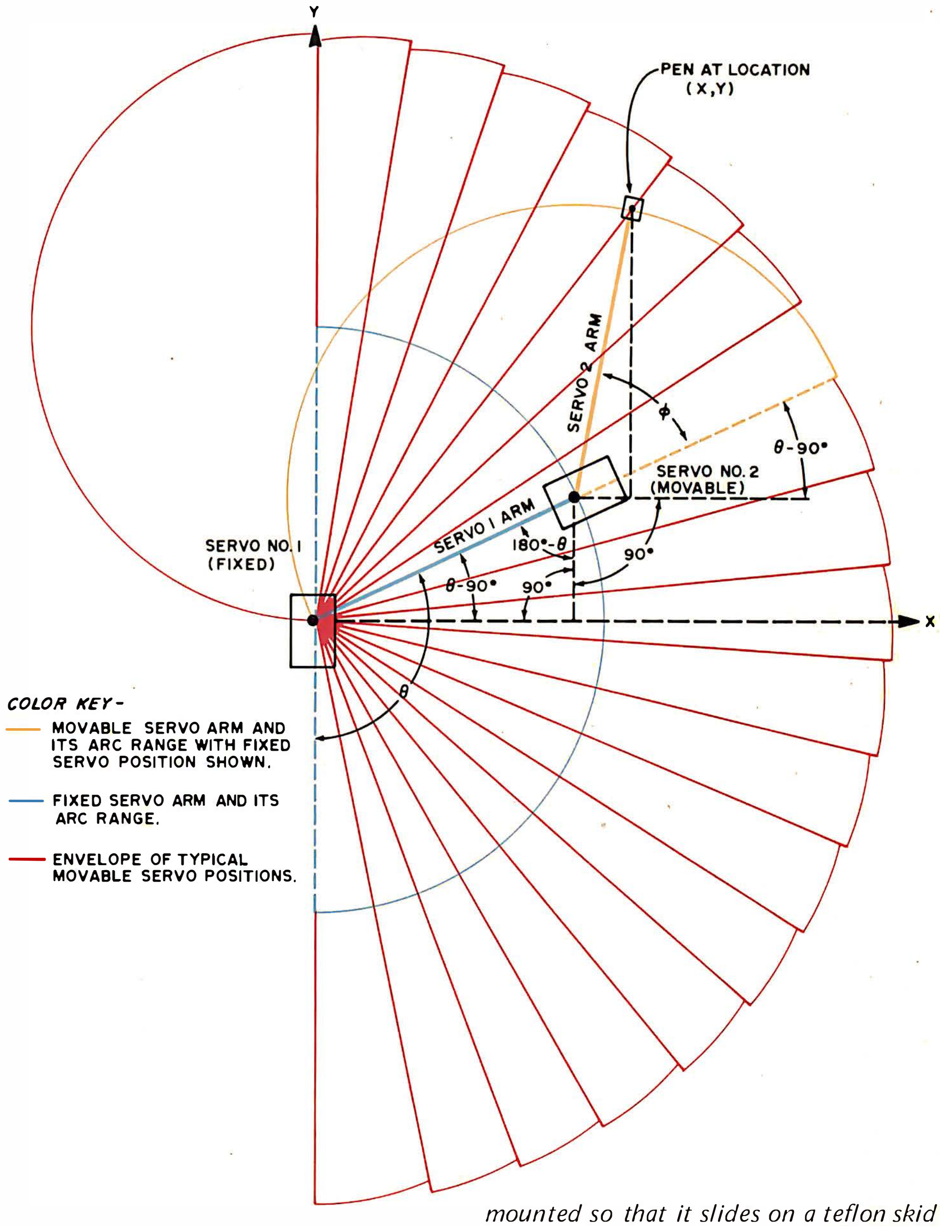


Figure 2: This diagram shows the concept of how to build a plotting bed based upon two model aircraft servomechanisms. The method of building consists of fixing one servo to the plotting bed, with a lever arm of length R. At the end of that lever arm, fix the second servo with a second lever arm of length R also. The end of the second arm should have a pen affixed to a solenoid mechanism or other actuator, allowing the pen to be raised or lowered. Due to weight considerations, the second servo should be mounted so that it slides on a teflon skid or rolls on some form of loose ball roller. The mathematics of calculating X and Y given angles φ and θ is shown in the drawing. To invert the calculation requires use of a reiterating calculation to a set of φ and θ values which solves the desired X and Y position. To use this plotter requires a system which has sufficient memory to run a fixed point trigonometric package with at least 16 bits of precision, assuming a 13 bit precision for the angular parameters of the servos.

follows: +5 V was the red wire, ground was the black wire, and the TTL output of PIA bit zero was used to drive the blue wire.

The results of the test are somewhat interesting. When this program was run, the servo was observed to have a total travel of 180° rotationally. A unique relationship between the integer pulse width parameter stored in DATA in this program and the shaft position was observed, but the minimum acceptable pulse width for the device we purchased was probably 1.3 ms. The reason for this conclusion is that the servo illustrated two regimes of settings: For counts of 00 to 19 hexadecimal (0 to 25 decimal) it swept out clockwise motion from 180° to 0° (relative angles). The motion was partitioned into very noticeable and large steps over this range. Then, from counts 19 to D6 the servo swept counterclockwise from 180° to 0° with what looked like roughly linear steps. This range of 189 steps is about 0.95° per step. At the high end of the count range, D9, the servo hit its limit stop. Thus, based on this experiment, the actual numbers work out as follows:

Minimum pulse width:
$1 + 0.012 \times 25 = 1.3$ ms

Maximum pulse width:
$1 + 0.012 \times 214 = 3.6$ ms

In using this servo, or any similar mechanism for an experimental project, readers would want to investigate the linearity of the position output with respect to the control parameter, and use a higher resolution timing method. For example, to make the world's least expensive plotter, using a 13 bit counter with a 2 MHz crystal clock, decimal counts of from 2600 to 7200 would cover the range of timing values found above, giving a control parameter range of 0 to 4600, approximately 0.04° per step assuming linear characteristics. Using trigonometry, this corresponds to an arc motion of 0.00683 inches per step at the end of a 10 inch lever arm (0.17 mm per step at the end of a 25 cm lever arm). Using two such servos, and working out the trigonometry of two connected lever arms, one on a servo fixed to the plane and one on a servo at the end of the fixed servo's lever arm, it should be possible to homebrew an XY plotter for less than \$100 by just buying two such model aircraft servos. Since I have no engineering specs yet on these devices, I can't say how accurate the plotter would be, but it would certainly draw! See figure 2.■

A 6502 Op Code Table

Lemuel A Fugitt
11316 Linares St
San Diego CA 92129

Here's a nice compact reference chart to help you debug those hexadecimal dumps from your 6502 microprocessor. To use the table, find the most significant digit along the top of the chart and follow the column down until you reach the value of the least significant bit of the hexadecimal code on the horizontal row. You now have not only the mnemonic but also the addressing mode being used. Table 1 is an explanation of the abbreviations used in the chart. ■

Table 1: An explanation of the abbreviations used in the 6502 reference chart.

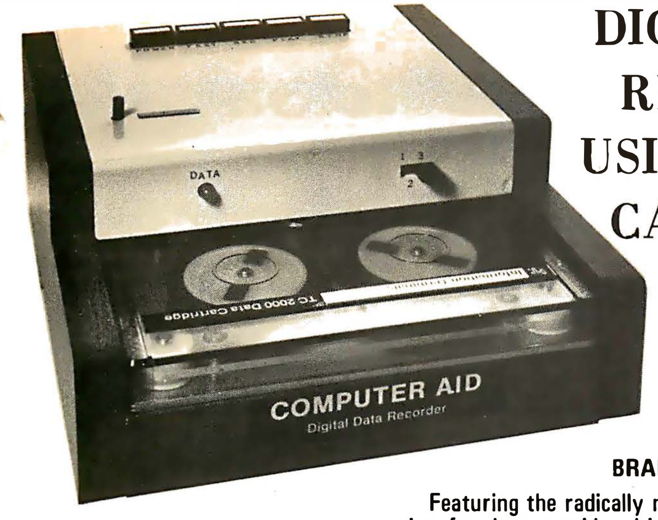
abs:	absolute.
abx:	indexed absolute using x register.
acc:	accumulator.
aby:	indexed absolute using y register.
i,x:	indexed indirect using x register.
i,y:	indexed indirect using y register.
imm:	immediate.
imp:	implied.
ind:	absolute indirect.
rel:	relative.
zer:	zero page.
zpx:	indexed zero page using x register.
zpy:	indexed zero page using y register.
*:	not implemented.

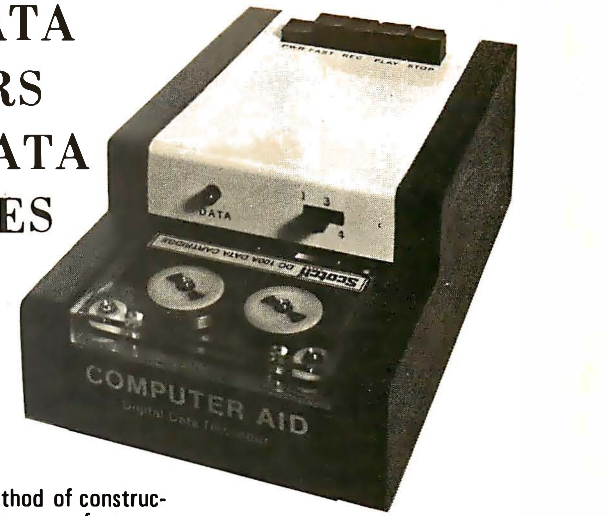
LEAST SIGNIFICANT 4 BITS

MOST SIGNIFICANT 4 BITS

	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0	BRK imp	BPL rel	JSR abs	BMI rel	RTI imp	BVC rel	RTS imp	BVS rel	*	BCC rel	LDY imm	BCS rel	CPY imm	BNE rel	CPX imm	BEQ rel
1	ORA i,x	ORA i,y	AND i,x	AND i,y	EOR i,x	EOR i,y	ADC i,x	ADC i,y	STA i,x	STA i,y	LDA i,x	LDA i,y	CMP i,x	CMP i,y	SBC i,x	SBC i,y
2	*	*	*	*	*	*	*	*	*	*	LDX imm	*	*	*	*	*
3	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
4	*	*	BIT zer	*	*	*	*	*	STY zer	STY zpx	LDY zer	LDY zpx	CPY zer	*	CPX zer	*
5	ORA zer	ORA zpx	AND zer	AND zpx	EOR zer	EOR zpx	ADC zer	ADC zpx	STA zer	STA zpx	LDA zer	LDA zpx	CMP zer	CMP zpx	SBC zer	SBC zpx
6	ASL zer	ASL zpx	ROL zer	ROL zpx	LSR zer	LSR zpx	*	*	STX zer	STX zpy	LDX zer	LDX zpy	DEC zer	DEC zpx	INC zer	INC zpx
7	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
8	PHP imp	CLC imp	PLP imp	SEC imp	PHA imp	CLI imp	PLA imp	SEI imp	DEY imp	TYA imp	TAY imp	CLV imp	INY imp	CLD imp	INX imp	SED imp
9	ORA imm	ORA aby	AND imm	AND aby	EOR imm	EOR aby	ADC imm	ADC aby	*	STA aby	LDA imm	LDA aby	CMP imm	CMP aby	SBC imm	SBC aby
A	ASL acc	*	ROL acc	*	LSR acc	*	*	*	TXA imp	TXS imp	TAX imp	TSX imp	DEX imp	*	NOP imp	*
B	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
C	*	*	BIT abs	*	JMP abs	*	JMP ind	*	STY abs	*	LDY abs	LDY abx	CPY abs	*	CPX abs	*
D	ORA abs	ORA abx	AND abs	AND abx	EOR abs	EOR abx	ADC abs	ADC abx	STA abs	STA abx	LDA abs	LDA abx	CMP abs	CMP abx	SBC abs	SBC abx
E	ASL abs	ASL abx	ROL abs	ROL abx	LSR abs	LSR abx	*	*	STX abs	*	LDX abs	LDX aby	DEC abs	DEC abx	INC abs	INC abx
F	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*

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*NOTE: You do not require an interface with the 3M1 and 3M3 unless you Phase Encode. But, you do need an interface to use the 2SIO(R) with your own audio cassette.

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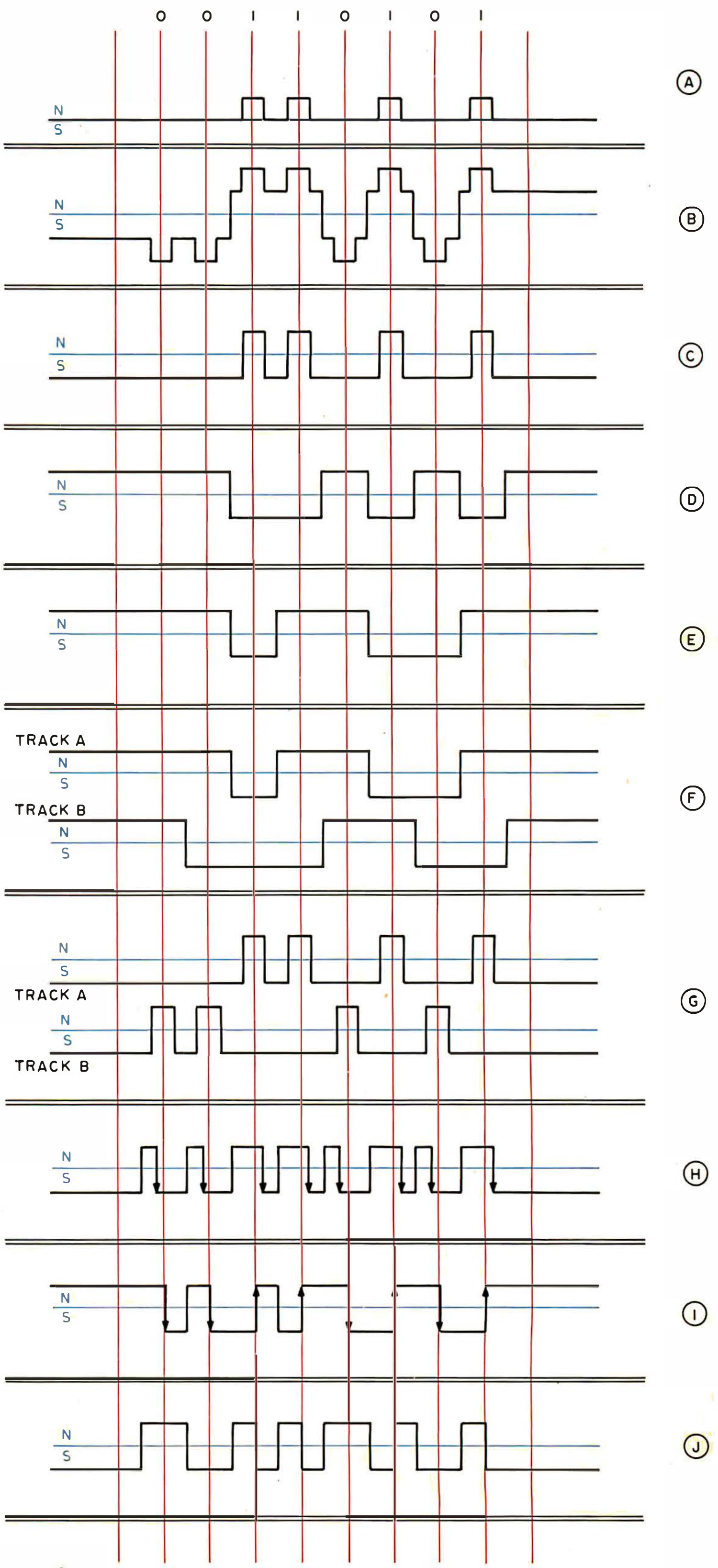
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The Digital Cassette

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Ira Rampil
917 Engineering Research Bldg
University of Wisconsin
Madison WI 53706



We've now seen an illustration of the techniques involved in the recording and playback of binary strings on magnetic tape (in part one last month). These techniques are all that would be required if the cassette tape transport mechanism had instantaneous start and stop, and perfect speed regulation. The read and write electronics would need to have very wide bandwidth, as shall be seen later, and the tape itself would have to be absolutely error free. Since there are problems in meeting each of these requirements, a great deal of effort has gone into data code conversion schemes that tend to alleviate the problems. Many different codes have been developed, but only a few have found widespread application and usage. The number of codes in use, in fact, is likely to decrease in coming years, as there are strong incentives in the industry to settle on standard coding schemes which would then be used by everyone. There is no urgent reason, however, for amateurs to embrace the industrial standard, especially if there is no intent to exchange tapes using the medium.

There are several specific qualities to examine when selecting a coding scheme. Dr A E Whitehouse of the Dept of Computer Science, University of Manchester, in his doctoral thesis, selected the following seven characteristics inherent in each scheme to which relative ratings can be assigned. These criteria are the column headings of table 1, which compares a number of coding schemes.

1. Bandwidth: The range of frequencies required to be passed by the read or write amplifiers for a given rate of data throughout should be minimal. Most importantly, low frequency response requirements should be avoided because
   a) low frequencies contain much noise like rumble, wow and flutter, and

Subsystem:

Part 2,

Digital Data Formats and System Considerations

b) difficulties in design of the read electronics. In general, the narrower the signal bandwidth, the better the signal to noise ratio. [Compare NRZ (nonreturn to zero) and PE (phase encoding) methods of encoding as seen in figure 1.]

2. Circuit Complexity: The cost of any system is proportional to its complexity. However, as can be seen in table 1, there are many performance trade-offs that improve with increasing complexity.
3. Efficiency: The efficiency of a code is a measure of data density produced by it. Efficiency: = 100 ÷ (flux changes per bit)
4. Inter Symbol Correlation: For the best performance, the codes used to represent binary ones and zeros should be as different from each other as possible. One hundred percent correlation occurs when the symbols used for ones and zeros are equal and opposite.
5. Noise: A qualitative measure of sensitivity to tape noises such as drop outs.
6. Read Resolution: The percentage of time in each bit that is allowed in order to decide whether it is a one or a zero.
7. Self Clocking: Does this code inherently provide its own bit rate clock for data reconstruction? If not, an external clock must be provided and

Table 1: Comparison of magnetic media encoding formats. This is an overall chart of several different characteristics; several of the methods are discussed in more detail in the text. In the waveform samples, the vertical lines mark data bit times, and the horizontal reference line separates north from south magnetization (or vice versa).

Code Name	Number of Data Tracks	Sample Wave-forms	Signal Band-width	Circuit Complexity	Storage Efficiency	Inter-symbol Correla-tion	Noise Immunity	Resolu-tion	Is It Self Clocking	Transport Speed Limitations	Applications and Comments
Return to zero (RZ, RZ pulse)	1	-A-	wide	simple	50%	50%	poor	poor	no	strict	Of historical interest, not self erasing
Bipolar RZ	1	-B-	medium	moderate	50%	100%	poor	poor	yes	lenient	Of historical interest only
Return to bias (RB)	1	-C-	wide	simple	50%	100%	poor	poor	no	strict	Of historical interest only
Non return to zero (NRZ, NRZ1, NREC)	1	-D-	wide	simple	100%	100%	fair	100%	no	strict	Used on older 7 and 9 track commercial magnetic tape drives
NRZ-mark (NRZM, NRZ1)	1	-E-	wide	simple	100%	75%	fair	100%	no	strict	Used on contemporary commercial tape drives
Complimentary NRZ (CNRZ)	2	-F-	wide	simple	50%	fair	fair	100%	yes	very lenient*	Incremental recorders and data loggers, calculator strip recorders.
Complimentary RB (CRB, 4 phase)	2	-G-	wide	simple	25%	50%	good	good	yes	very lenient*	Off line terminals; uses much tape due to low efficiency
Pulse ratio recording (PR, PW, SRT)	1	-H-	medium	moderate	33%	good	good	>=50%	yes	tolerant of slow drifts	Useful on hub driven tape drives (eg: Redactron)
Phase Encoding (PE, split phase, Manchester II+180)	1	-I-	narrow	complete	50%	100%	good	75%	yes	tolerant of fast and slow change	Currently the industry standard for all tape systems, commonly used for floppy disks.
Manchester I (also PE)	1	-J-	narrow	complex	50%	100%	good	75%	yes	tolerant of fast and slow change	Same as above.

*Note: Two channel recording methods are lenient with respect to speed variations, but have tight head skew requirements which do not exist for single channel recording methods.

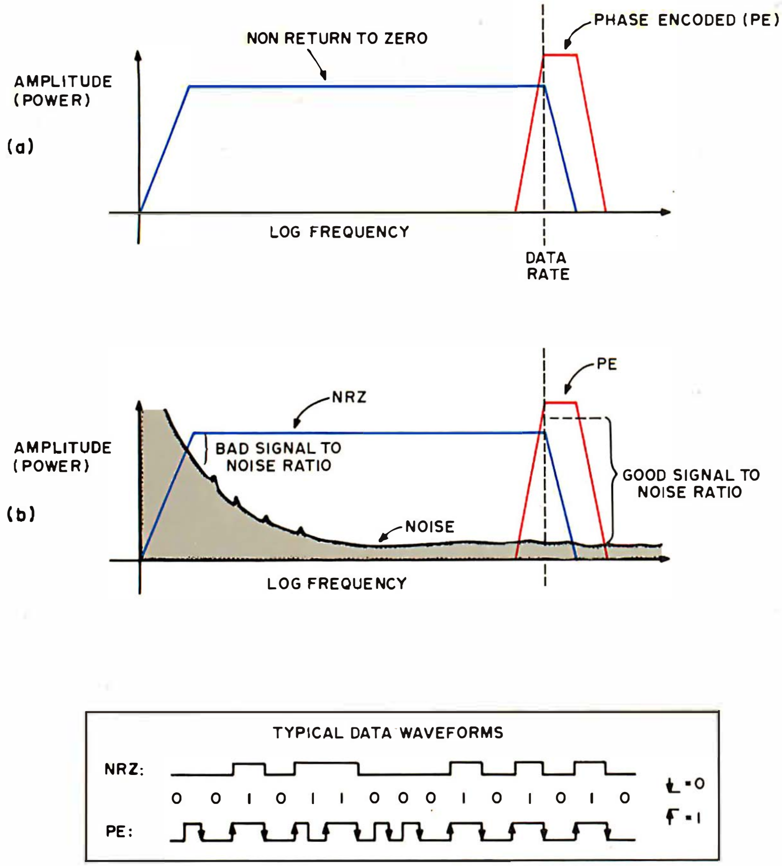


Figure 1: Frequency spectrum requirements for a practical system depend upon the nature of the encoding and the noise characteristics. At (a), two common encoding methods, non return to zero (NRZ) and phase encoded (PE) data are shown as a spectrum of amplitude versus frequency. NRZ requires a flat response virtually from zero frequency up to the data rate. PE requires a frequency band response characteristic of one octave in the vicinity of the data rate. Looking only at the signal, and knowing electronic design rules of thumb such as the one that it is easier to make a narrow band amplifier than a wide band one, PE looks like a better method. Then, adding in a system noise characteristic as at (b), it becomes obvious that PE or any system with limited bandwidth is to be preferred over NRZ. NRZ is the simple method to generate (it is just a time ordered stream of data bit values), but its signal to noise ratio runs into problems due to noise at the low frequencies.

since it is asynchronous to the data, this code cannot be used reliably at high data rates.

For additional information beyond Whitehouse's criteria, two extra columns have been added to table 1.

8. Tape Transport Limitations: What requirements does this particular code place on tape speed accuracy and stability?
9. Usual Application: These various coding schemes present different trade-off balances, and therefore have found themselves in a wide variety of different applications. A typical application is presented for each code.

To efficiently analyze the entries in the table, it is possible to divide them into two groups. The division concerns the number of tracks required to write or recover data. Some codes require two channels of recording to recover one channel of data. These codes are, for the most part, older and space inefficient techniques. The advantage in using them is that the coding circuitry is relatively simple and these codes tend to be very speed tolerant. For the amateur, however, the cost reduction in logic is more than offset by the additional cost of a two track tape head, an extra signal processing channel, and the problem of intertrack head misalignment or head skew as illustrated in figure 2. Therefore, with the advent of quality low cost tape transports and speed tolerant one track codes, it is wisest to stick with single track recording. There is an exception called "mark track" recording which will be discussed later. There are four techniques which have found application among amateur applications.

Non Return to Zero (NRZ)

Conventional NRZ consists of recording a constant saturated level for the duration of the bit. For example, a string of ones input to the cassette will be recorded as a constant north magnetic level which will persist until a zero occurs in the input string. Obviously the efficiency is high; there is a maximum of one transition per bit, usually less. The possibility of long strings of either zeros or ones requires that the signal processing chain have a very wide bandwidth, extending down to near zero frequency. Another problem with this system is that it is not self clocking, therefore an asynchronous receiver such as a UART must be used to convert the output of the tape back to synchronized parallel bytes. Assuming a very stable tape speed, both in the long term and short term, this technique is limited by tape noise, the magnetic data transfer head, and the limiting speed of the UART. There is a way of improving the reliability of asynchronous NRZ by making it synchronous: Recording a separate clock track at the data rate while simultaneously recording data in another channel provides a means of synchronously gating the data at playback, thus eliminating the need for a UART (assuming skew is not a problem). The National Multiplex Co of South Plainfield NJ provides amateur digital cassette recorders using NRZ or clocked NRZ at up to 2400 bits per second; they also sell NRZ electronics boards that can be planted in an ordinary audio tape recorder. This product is capable of up to 4800 bits per second, depending on tape speed.

Complimentary Return to Bias (CRB)

Complimentary return to bias is a two track technique which resembles the RB code. In RB each data cell has a binary state, north or south, and so in two track CRB each data cell is set to one of four states:

1. Both tracks at south
2. Track A at south, track B at north
3. Track A at north, track B at south
4. Both tracks at north

State 1 represents a "no data" condition as in an inter record gap. States 2 and 3 respectively represent zero and one. State 4 is a framing signal which can be used to represent conditions like end of block or end of byte. This code is both noise and speed tolerant. Its clock signal can be derived from a simple OR of both tracks, since except in state 1, there are transitions every bit. This code, however, has poor utilization of available tape. In other words, it is a low density technique and the bandwidth is even wider than for NRZ. As a two track technique it is subject to skew problems. The circuitry to implement CRB is a fairly simple logic network.

Pulse Ratio Recording (PR)

In the pulse ratio coding method each data cell uses two flux transitions in three possible locations. The first flux transition of each cell is a positive transition, from south to north. Its presence defines the beginning of the data cell and gates a clock on. The contents of the data cell, ie: the bit, is determined by the percentage of time spent at north as compared to south, within each data cell. There is a very simple method to decode PR by the use of a bidirectional counter in hardware or software. The previously mentioned positive flux transition starts the counter going up. The next flux transition is of course a negative one. Its arrival switches the mode of the counter into down counting. The transition after that is the clock pulse for the next cell; it resets the counter and clocks out the contents of a flip flop which records the possible transition of the $\overline{\text{BORROW}}$ output of the counter – then the process starts over. It is the borrow signal which contains the data in the cell. If for a one bit, as in table 1, the north time was greater than the south time, then the counter result is a positive number; no borrow was required and the flip flop holds a one, the contents of the cell. A zero on tape has a longer south time than north time: The counter going into underflow drops the $\overline{\text{BORROW}}$ to zero for one clock cycle. The flip flop records the drop and holds a zero. This method provides excellent resistance to long term speed variations, provided the counter has enough precision. The bit-to-bit jitter resistance, however, is not so good due to the less than 50% read resolution. This resistance and resolution can be improved by accentuating the pulse width difference; but then noise immunity suffers because the bandwidth goes up. This technique's primary advantage is that the circuitry is the simplest for a one track self clocking code.

Phase Encoding (PE)

Phase encoding has been selected by all of the relevant standards organizations as the way to go. Most commercial manufacturers provide a PE option for their cassette decks sold to original equipment manufacturers (OEMs). The most widely used form of PE, also known as "split phase" or "Manchester II +180" is a single track, self clocking technique. The definition of the code places two landmarks in each data cell. The landmarks are actually times during a data cell when transitions are made in the tape magnetization level. The data is actually stored in the direction of the magnetic transition at the midpoint of the cell. This transition occurs at "data time" and is specified as south to north for a one, and north to south for a zero. In order to assure that the magnetic signal will be at the right

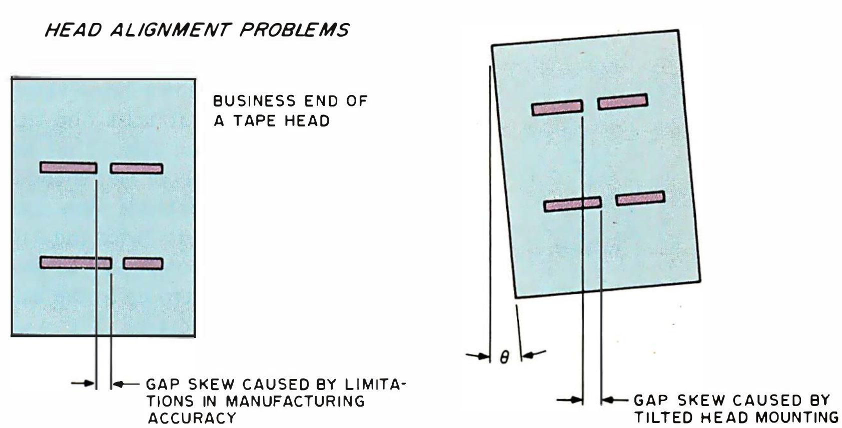


Figure 2: Head alignment and manufacturing tolerances cause a phenomenon called gap skew in multitrack heads. At (a), the tolerances in manufacturing of the head itself cause one component of skew. At (b), a second source of skew is due to the fact that the head may not be perfectly mounted relative to the tape. The tilt causes a skew between otherwise perfectly manufactured gaps. The actual skew measured is a combination of both effects. The picture is exaggerated, but a small misalignment of, for example, 0.005 inch (0.13 mm) means a difference of 200 ms in the relative timing of two tracks being read at 25 inches per second (64 cm per second). A typical manual for a tape drive unit will warn the controller builder to put in circuitry to compensate for intertrack skew totalling several bits if parallel data is used. This skew problem argues strongly in favor of single track recording techniques.

Sample Circuitry for Several Different Coding Techniques

This circuitry assumes that the tape deck write head is driven directly for output, and that tape input signal processing electronics produces the + and − flux transition clocks (low going) as output. Encoding consists of preparing the proper signal to drive the write head from NRZ data, and decoding consists of converting the flux transition information back into NRZ data, possibly along with clock information derived from the tape.

a) NRZ coding. The output NRZ data simply drives the head directly. A UART or other asynchronous data format must be used for the parallel to serial conversion, and clock references used in writing are assumed to be valid within a few percent when reading the data back, hence the tight tolerances on speed. Decoding of the flux transition clocks is done simply by driving an RS flip flop.

b) NRZ1 coding. The output NRZ data is converted to NRZ1 by using it to gate the clock driving a toggle flip flop (here a JK flip flop set up to toggle). The input flux transition data is converted back to NRZ by using the logical OR of the two transition clocks to drive a retriggerable oneshot with period (R and C) set up equal to the bit period. The fixed width of this oneshot also makes this method highly speed dependent.

c) PE coding. The output PE data is generated

polarity for the next data time, an additional transition can occur if needed at "phase time." Phase time occurs at the beginning of each data cell. The phase transition occurs at phase time only if the preceding bit is the same as the bit to be written. The phase bit is ignored by the read circuitry except for clocking purposes. In the inevitable comparison of phase encoding with non return to zero, it first appears as though non return to zero provides high bit density per unit length of tape. True, phase encoding is less space efficient than non return to zero, requiring the time budget of two flux transitions per data bit compared to one flux change per bit. There are, however, extenuating circumstances which throw the balance in favor of phase encoding. The advantages come from phase encoding's requirement that each data cell have at least one flux change and not more than two. Thus the bandwidth needed for a phase encoded signal processing chain extends only one octave, from the data rate to twice the data rate. The bandwidth for non return to zero electronics extends from zero up to the data rate, possibly 5 to 10 octaves. The wide range of flux change frequencies also wreaks havoc on peak shift and amplitude fluctuation phenomena due to the tape itself. As we saw previously, peak shift and amplitude fluctuation cause problems in the recovery of raw bit strings from the tape. These phenomena are well defined in phase encoding: Their effects are small and easily compensated. Self clocking is another side benefit of having at least one transition per bit. A very simple form of self clocking derived from phase encoding is a monostable set to the data rate. Triggered by each data transition, its output provides clock gating for each previous data bit. More sophisticated techniques which have great tolerance for tape speed variation and noise involve tracking oscillators or phase locked loops. Such systems will compensate for missing pulses by providing clock pulses of their own if the tape messes up momentarily. Phase encoding requires that the first byte written in each block be a preamble word consisting of 8 data transitions like the byte 01010101. The preamble allows time for the phase locked loop to get into lock step with the data rate. Block diagrams for various forms of data encoding and recovery will be illustrated later.

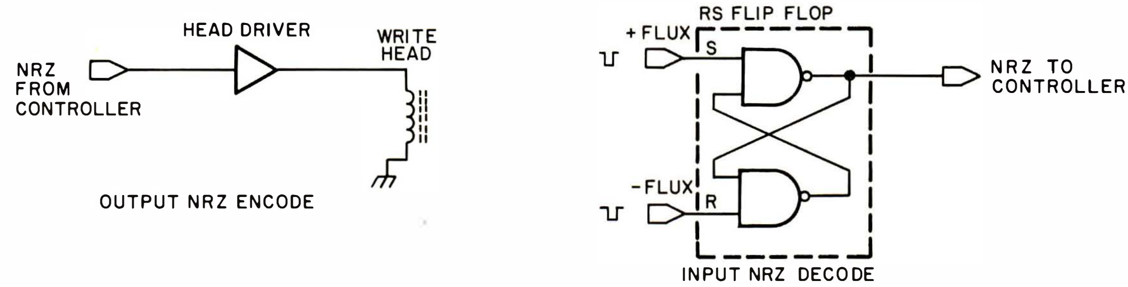
Since they have now appeared on the personal computing market, a few words are in order concerning GCR, Group Coded Recording. GCR is different from the previously discussed codes in that here code bits do not bear a one to one correspondence to their input bits. Instead, a code converter ROM, like an ASCII to EBCDIC converter, transforms each parallel input group into a slightly longer output group which is then put on the tape. Playback involves the opposite process. This type of coding was originally developed for ultra high performance nine track drives and combines the best features of phase encoding and non return to zero. The circuitry, however, is very complex.

Error Detection

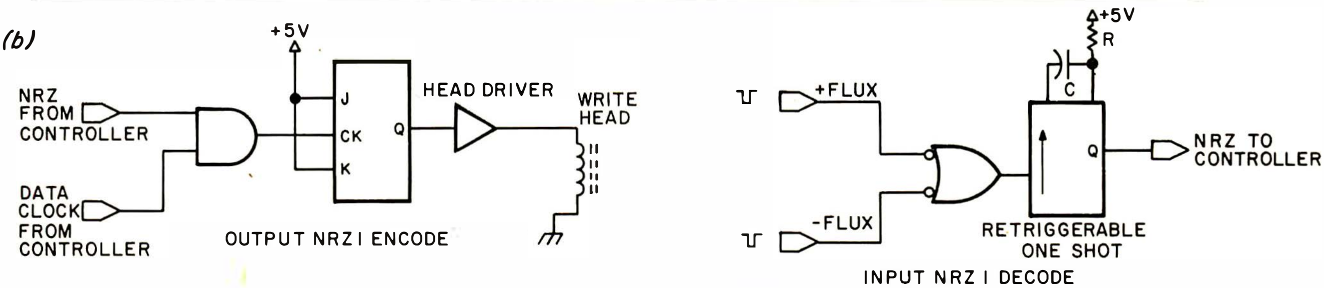
There is no easy and cheap method for self correcting data errors that occur on tape read operations. There are redundant data techniques which would work but at a great sacrifice in data throughput. On the other hand, there are several ways of detecting errors. This is almost as good as correcting the errors, since about 9 out of 10 errors are soft errors; that is to say they disappear upon retrying the read. Only about 1 in 10^7 to 10^9 bits read result in a hard, or permanent, error. There are also two very

from NRZ data using a clock at twice the data rate, and the NRZ data itself. Two methods are shown here, one which can be built from gates, and a second using an RCA CD4037A integrated circuit. The input decoding methods can range from the simple oneshot method shown here to complicated phase lock loops which are much more error resistant. For the oneshot version, ΔT should be set to be 1.5 bit cells.

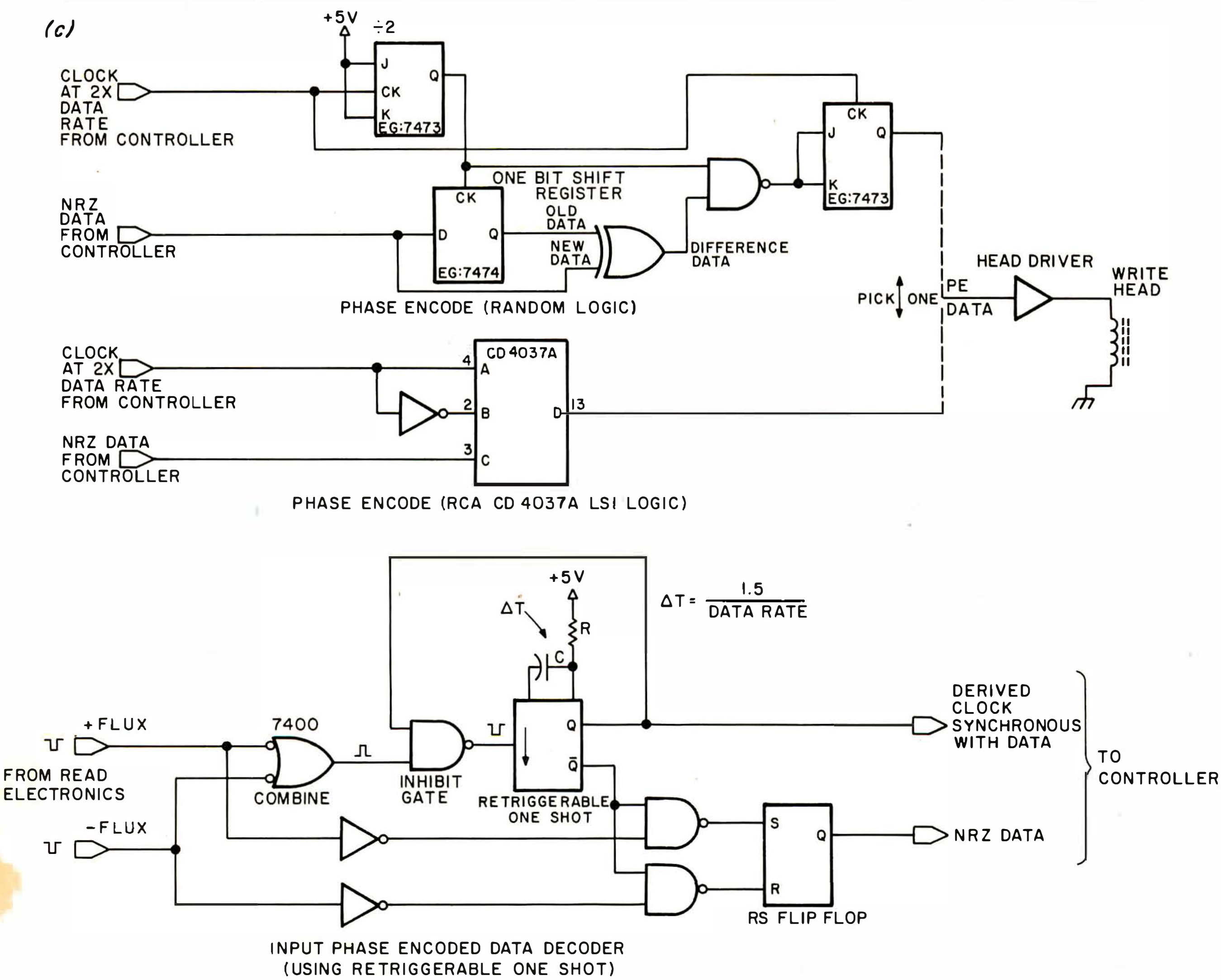
(a)



(b)



(c)



```
                         1100----------------100001 R    0001011000000110
1100000000000000101    )11110-----------------100011         (CRCC)
(CR-16 POLYNOMIAL)           (DATA BLOCK)                    16 BITS
 17 BITS LONG                n BITS LONG
```

Figure 3: A hypothetical cyclic redundancy check polynomial division. In a CRC calculation, the data is divided by a 17 bit cyclic redundancy polynomial to yield a result and a 16 bit remainder term. It is the remainder term which is used as the check word for error detection. The beauty of the whole method lies in the fact that it is very easy to perform the division in hardware, one bit at a time as the serial data goes flying by. There are even LSI circuits which can be used in the hardware of a controller and formatter device.

inexpensive precautions to take to prevent errors:

1. Keep all tapes immaculately clean. Don't ever smoke in their presence. The smoke particulates are murder to magnetic tape.
2. Always rewind tape before removing from the drive. This helps prevent dirt and crinkles from affecting the tape.

Three methods of error detection particularly apply to cassette operations. Only one method need be used at a time. The first technique is the commonly used parity bit. A parity bit is simply an extra bit tacked on to each byte of data. An odd parity system sets the parity bit to one if the one's complement sum of the data bits in the byte is equal to zero. In other words, the parity bit is set equal to one if there is an even number of one bits in the data byte. During a read operation, a new parity bit is generated and compared to the parity bit written previously on the tape. If they are different there is an error somewhere. The disadvantage of a parity check is that it will not detect an error if an even number of bits in a single byte is wrong. Another disadvantage is that a parity bit per byte eats up 11.1% of the available room for data. For blocks longer than 16 bytes, there are more efficient techniques which use two bytes per block regardless of block length. These techniques are the checksum word and the cyclic redundancy check (CRC) word. The checksum technique simply sums all the data in the block, byte by byte, module 2. The resultant n bit sum is written on the tape as the last information in a block. During a read operation, the data is again checksummed as it enters the computer and the new result is compared to the sum on tape. Again, a mismatch indicates an error has occurred somewhere along the line.

Although the theory of cyclic error codes is somewhat complex for discussion here, the following is a fairly simple explanation of how cyclic redundancy checks work. Consider any random block of data to be a binary polynomial of degree N, where N + 1 is the number of data bits in the block. A CRC check is performed by serially dividing the entire data block (modulo 2) by a binary polynomial of degree 16. Such a polynomial could look like "11000000000000101," which happens to be the standard CR-16 polynomial otherwise represented as $X^{16} + X^{15} + X^2 + 1$. This division process is

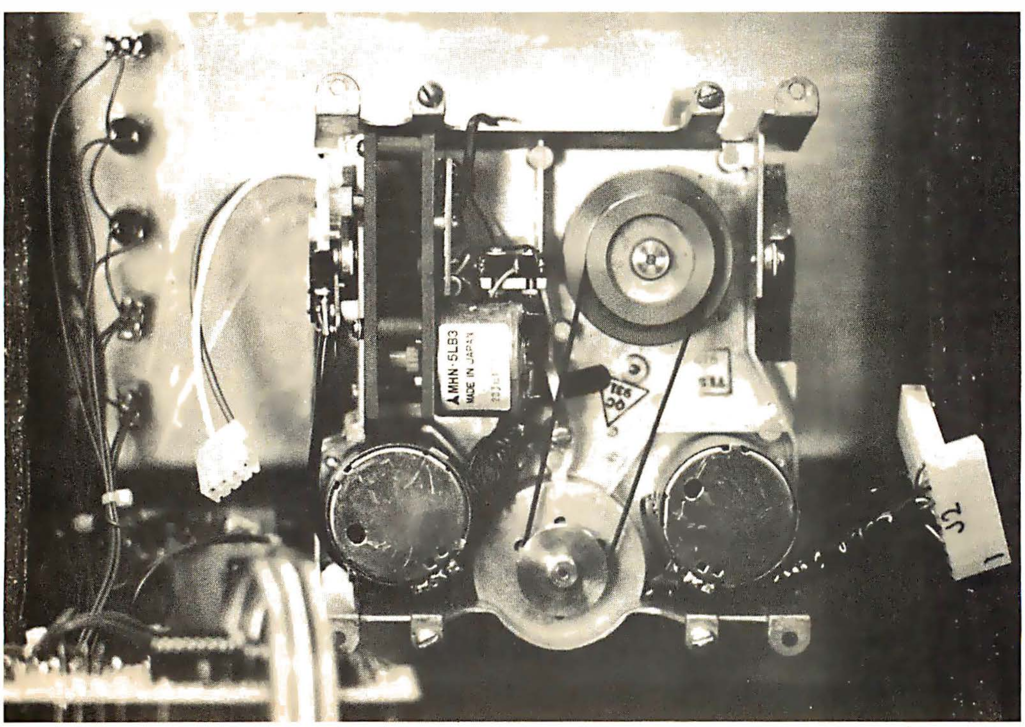


Photo 1: The works of a Phi-Deck mechanism, viewed from the rear. The four DC motors of the drive can be seen in this photo: Two are used as direct drive for the tape reels, one drives the tape capstan via the pully and belt arrangement seen, and the third drives a gearbox which actuates the tape head engage mechanism. For a view from the front, see photo 2.

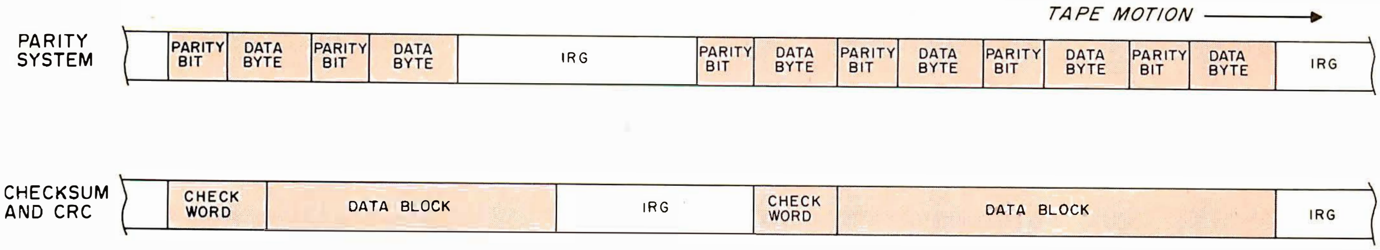


Figure 4: The relationship of error detection data to data constitutes the beginning of a format for the tape data. In a parity system, each data byte has an extra parity bit associated with it, and blocks of data are just groups of such data and parity combinations between inter record gaps. In a checksum or cyclic redundancy check system, the data bytes have no detail error detection code associated with them and a single check word, with enough bits to guarantee error detection given the size of the block, suffices. Cyclic redundancy checks are easily generated in hardware, and checksums are the easier route given software as the means of error detection.

illustrated in figure 3. Each unique data block generates a unique 16 bit remainder term after division. The remainder word, or cyclic redundancy check character (CRCC), is written out to tape and is compared to the CRCC freshly generated during a read operation. Once again, a mismatch signifies an error. A CRC generator and checker can be implemented in either hardware or software. Several manufacturers such as AMI, Motorola and Signetics offer LSI chips which do the whole job in one package containing a shift register and some gates, so CRC is best left to hardware. CRC with the 17 bit polynomial is capable of detecting any number of single bit errors and a large portion of any "burst" (multibit) errors that occur in a block less than or equal to 4096 bits long (for a 16 bit cyclic redundancy check code). CRC is fast becoming a standard for floppies and commercial cassette equipment due to its ease of generation in hardware.

The relationships of the error detecting codes to the data they protect is illustrated in figure 4. It is important to keep in mind the completely serial nature of such single track recording.

Tape Transport Hardware

The choice of hardware is another place in which many alternatives are possible. Ordinary audio cassette decks have excellent speed regulation, but they have low tape speed; and included in their price are expensive audio recording and playback amplifiers which are not needed for digital service. In additional, rare is the audio deck which permits digital control of the mechanism. Most decks designed for digital service have good speed regulation, high tape speed, and full digital control of tape motion. Their problem, in terms of amateurs, is price. The majority of digital cassette decks start in the vicinity of $500 for the deck itself and a circuit board with the motion control logic. Some decks provide tape transfer heads with preamps on the read side; some do not. Most manufacturers offer at additional cost a data encoding and decoding board. Power supplies, although usually trivial, are not cheap. Fortunately, there are currently available several inexpensive cassette decks which meet all of the requirements for digital service. One such unit is the Phi-Deck, from the Triple I Company, which has a current price tag, for the same package mentioned above, of between $200 and $300. The deck itself was originally designed for audio use in a language lab environment where remote control and good speed regulation are important factors. With the addition of regulated high speed (up to 20 inches per

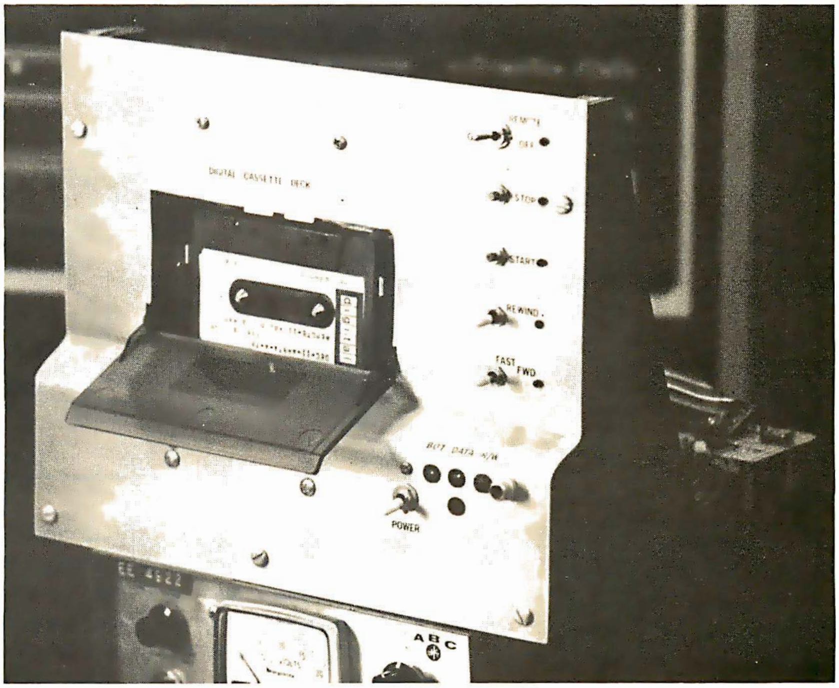


Photo 2: Ira Rampil's homebrew mount for the Phi-Deck mechanism he will be using with his PDP-11/20 system as a mass storage file subsystem.

second), the deck is fully adequate for digital use. Since the Phi-Deck is representative of a large class of deck hardware and is itself likely to be the first choice of personal computing equipment designers, a few words could usefully be spent in a description of the deck.

The Phi-Deck obtains its speed regulation from a tape capstan as do audio decks. Many other digital decks use a hub to hub drive technique which then requires a servo loop for speed regulation. The capstan is controlled by a separate motor, as are each of the reels. The head is also controlled by a separate motor to engage and disengage it from the tape. A motion control board receives signals from the processor such as forward, rewind and stop. It converts these control signals into the proper sequence of voltages to control the small DC motors. The control board also relays back to the processor various status lines to confirm that the deck is operating as instructed. The innards of the Super Phi-Deck are pictured in photo 1; photo 2 shows a Super Phi-Deck in a mounting designed by author Rampil for use in his personal PDP-11 based system. Figure 5 illustrates the deck in its relationship to the rest of a cassette memory system.

Data Formatting and Applications

Once a means of recording and recovering data on cassette tape is secured, some decisions must be made on the formatting or layout of data on the tape. There is a wide variety of possible formats. The one to select depends on the application. Whatever the application, the overall tape format should be as represented in figure 6: clear leader, blank tape, strings of recorded data separated by inter record gaps (IRG), blank tape, and finally clear trailer. Certified digital cassette tapes and cartridges have small holes punched in the tape at the beginning and end of the usable magnetic surface. Essentially, the application dependent variable is the way the data is grouped on the tape. Grouping data into blocks is a key feature of most tape memory systems.

The concept of blocking began as logical records being stored as separate entities on tape. Storing an entire program, for example, as a contiguous string of data separate from other logical records, has some merit. A block has clearly defined starting and end points, and thus eliminates word by word searching through an entire tape to find and process a particular program. As the hardware and the operating systems grew in sophistication, the concept of buffering was applied to input and output operations. Buffering is the process by which data from the outside is first read into a dedicated area of main memory by a monitor program, checked over, and then forwarded to the program which initially requested the data transfer. For example, if a program wishes to read some data points from the cassette memory, a subroutine call is placed to the monitor program requesting the read, the monitor does all the work of finding and reading the data, checks it for errors, and then relocates it to the appropriate locations inside the requesting program's memory

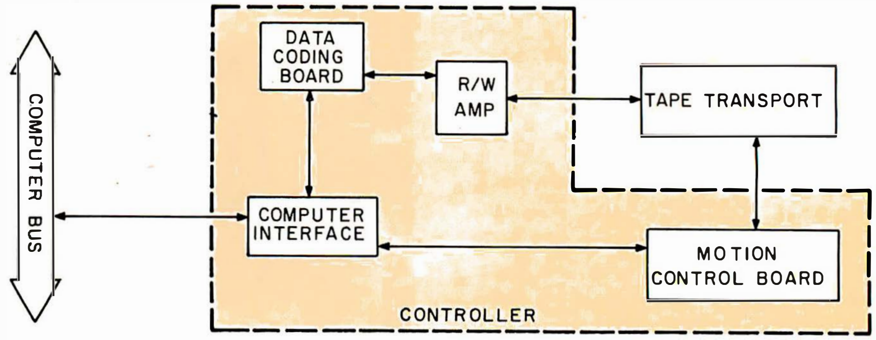


Figure 5: An overall block diagram of a digitally controlled magnetic film memory subsystem. The addition of complete tape motion control and use of direct digital recording make such a Philips cassette subsystem a vast improvement over the manually oriented lower speed audio versions of tape mass storage. Functionally, this same block diagram applies whether the drive is for a reel to reel tape, a Philips cassette, or 3M cartridge or other magnetic media. The next step up in terms of performance (and price) is probably a floppy disk. A floppy disk subsystem has a very similar arrangement, but a slightly more complicated motion control section needed to manipulate its movable head.

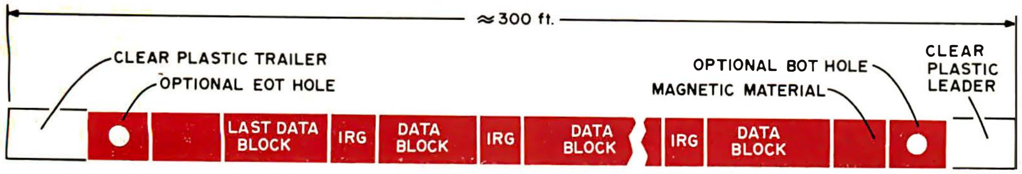


Figure 6: The anatomy of a Philips cassette recording. At the beginning and end of the tape is a clear plastic leader area. The magnetic tape (symbolized by the black area with dropped out lettering) has an optional EOT (end of tape) hole at each end. Data is typically grouped into blocks, separated by inter record gaps (IRG) which are erased regions without data. The content of the blocks is specified by software and hardware depending upon the particular system used.

space. Although the advantages of buffering IO are beyond the scope of this article, it should be sufficient to say that they are important. Except in very large commercial machines, buffer areas are seldom large enough to contain an entire program as a single logical record. Therefore, logical records are often broken up into several smaller blocks on the tape. Not only is the requirement for buffer memory reduced; but in addition, error handling is easier. Conversely, if the logical records are very small, for instance, one output character data, the buffering software collects several outputs together and ships it out to the tape as one block. The number of logical records per tape block is known as the blocking factor. Effective blocking represents a compromise between the smallest buffer area and the maximum tape utilization, ie: the minimum number of blocks and their associated inter record gaps. A graph portraying the approximate relationship between the length of data blocks, assuming they are all the same fixed length, and the total data capacity of a C-30 cassette is presented in figure 7.

The simplest application lends itself to the simplest formatting. A digitally controlled cassette system or manually controlled system may be used as an inexpensive substitute for a high speed paper tape reader punch. In fact, several manufacturers offer cassette systems that are plug compatible with paper tape equipment. The data is blocked byte by byte, or not at all. Since there is no file structure, the data appears on the cassette exactly as it would on paper tape. There is no need for inter record gaps between bytes in this format, for by placing very long gaps between logical records on the order of a foot or two of tape a human operator can locate a particular logical record with the aid of a tape counter mechanism, just as an audiophile would find a particular song. A UART is a very neat way to generate the parallel-serial data conversion for this byte oriented format. The disadvantage of using a UART here is that it adds at least three extra bits, start, stop and parity, to every byte thus reducing the data density on the tape.

For more efficient and useful operation, a file structure should be added to the digi-

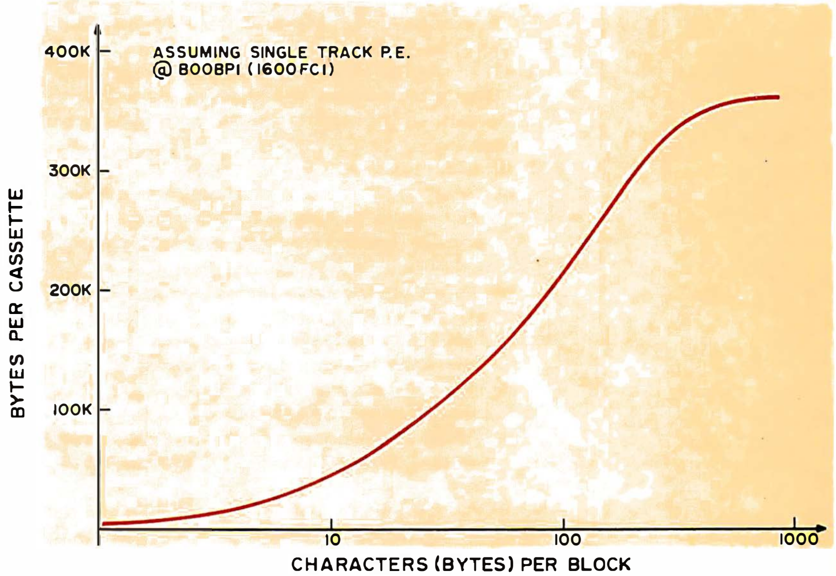


Figure 7: Cassette capacity versus block size. The inter record gap (IRG) is essentially wasted space on the tape. By increasing the size of the block, the percentage of tape wasted on IRGs declines toward a limit of zero. As the size of the block is decreased (ultimately to its limit of a single byte separated by IRGs on either side) the total number of bytes available on a tape declines. For any given set of parameters (inter record gap length in inches, flux density in bits per inch, and data format), the total useful data per cassette can be calculated and plotted as one point on a curve such as this.

tally controlled transport. By blocking the data into chunks of convenient size with identification information, software can then examine each buffer as it is read in to search for any particular file (a group of such blocks) on the tape. A file is considered to be a single logical record even though it might cover many blocks. In a file structured system with a remotely controlled tape deck, keyboard commands or commands generated by a program replace manual intervention and the automatic operations make the system much more convenient. Still lacking, however, is a very useful block replacability feature since there is no way to synchronize the start of overwriting with the beginning of a data block, especially if the drive has stopped in the preceding gap. Although it is not possible in this system to overlay a corrected or updated program into the space it formerly occupied, it can easily be added on to the end of the tape.

Musings on the Ultimate

The ultimate cassette memory system incorporates block replaceability and sector addressing to simulate random access storage. The technique proposed here for Phi-Decks is similar to that used so successfully by Digital Equipment Corporation in their DECtape units. In fact the Sykes Corporation developed and marketed such a system for cassettes until their attentions turned to floppy disks. The trick is use one track for normal phase encoded or pulse ratio data and a second track as a prewritten mark track. The mark track is first written to initialize the tape and it is only read thereafter. It contains, in the same code as the data track, various sorts of delineators, or marks, and also the block address numbers of the data blocks residing on the adjacent data track(s). Data is written in fixed sized blocks in synchronization with the areas designated by the mark track. By observing the transitions on the mark track, the tape controller will have no difficulty in overlaying or replacing previously written data. The advantage of including block numbers on the mark track is that as they are read in, they can easily be compared with a register containing a block number being sought, thus eliminating the need for a software search program. Usually a directory data block is included on the tape, most frequently as the first data block. Its contents generally include the file names and their starting block addresses. When a cassette is first mounted in the drive, its directory is read in. Whenever the computer needs access to a tape file, it gets the block address from the directory and initiates a hardware search. Each time a change is made to the tape, the directory copy in memory is updated and a copy of it is written back to the tape. Using one's imagination, many different file manipulations are possible with such a system. Anything possible with a floppy disk operating system is in fact possible with a mark track cassette system. The tradeoff is just time versus price. A floppy is essentially instantaneous, from a human standpoint. A cassette system takes from seconds to a few minutes, at about one fourth the price of a floppy. Even with these time constraints, a full digital cassette system is a lot less painful than Teletype paper tape or audio cassette.■

FOR FURTHER READING

Books

Bycer B B, *Digital Magnetic Tape Recording: Principles and Computer Applications*, Hayden Co, NY 1965. This book has an excellent introduction to the theory, but the chapters on applications are heavily dated.

Sebestyn, L G, *Digital Magnetic Tape Recording for Computer Applications*, Chapman and Hall Ltd, London, 1973, an unimposing but very usable modern reference; a book shelf must for the designer types.

Commercial Literature

1. Memodyne Corp, Newton Upper Falls MA, "Recording Binary Code on the Philips Cassette," an 11 page brochure.
2. MFE Computer Access Systems, Salem NH, "Applications Notes #63 to 66" a pro and con discussion of cassette decks and recording techniques.
3. Motorola, Mesa AZ:
   a) "M6800 Microprocessor Applications Manual," includes the complete design of a possible cassette memory system including software.
   b) "Phase Locked Loop Manual," discussion of using PLLs for PE decoding.
   c) "MC3467, MC3468 Applications Notes," monolithic magnetic tape read chains.
   d) "MC4044 Applications Notes," using a PLL phase detector in PE decoding.
   e) "MC8521 Preliminary Data Sheet," not yet released, but a complete PE decoder on a chip.
4. RCA, *COS/MOS Data Book,* "Applications Note ICAN6101, ICAN6210," PE decode/encode using CMOS.

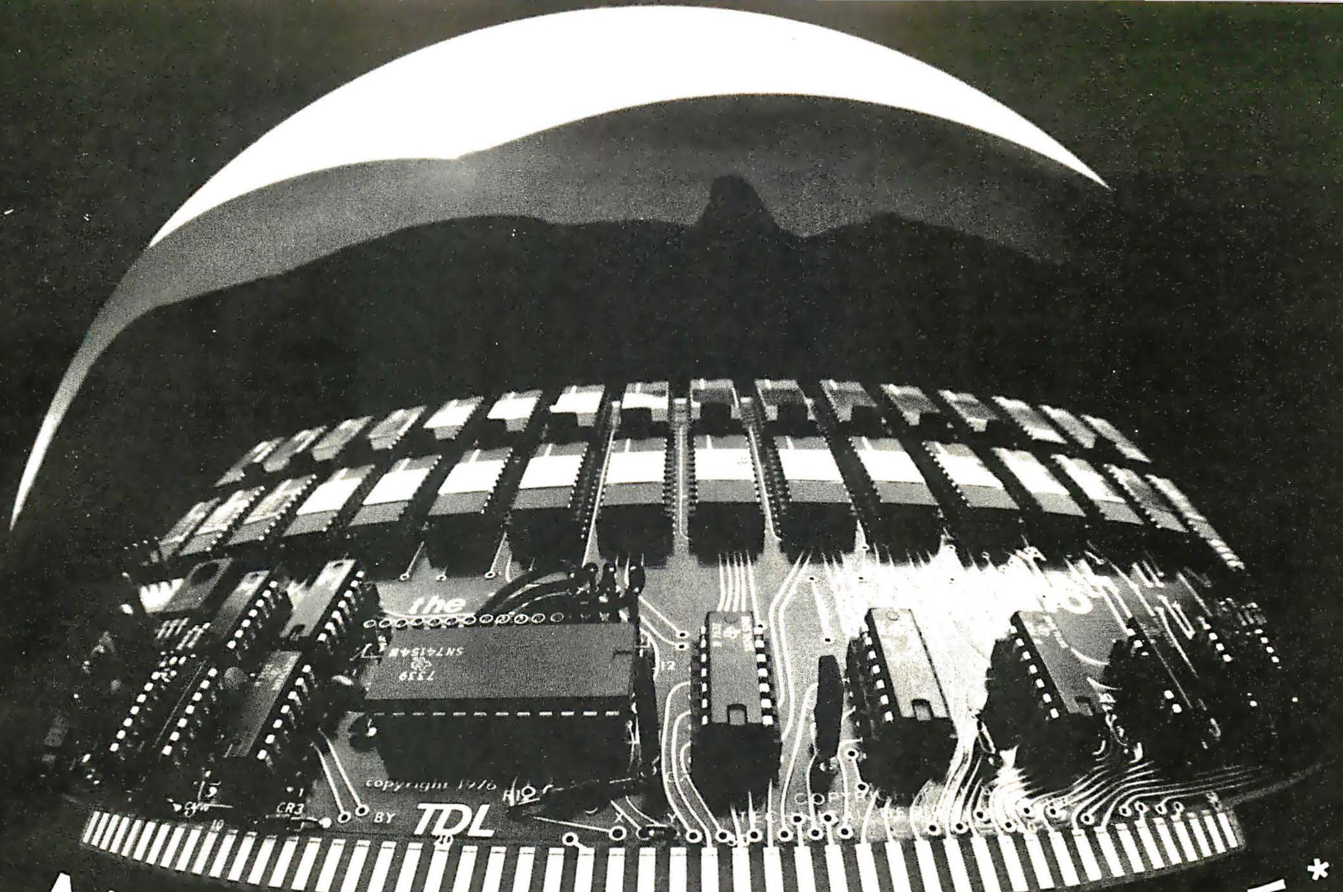
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The Economy Company.



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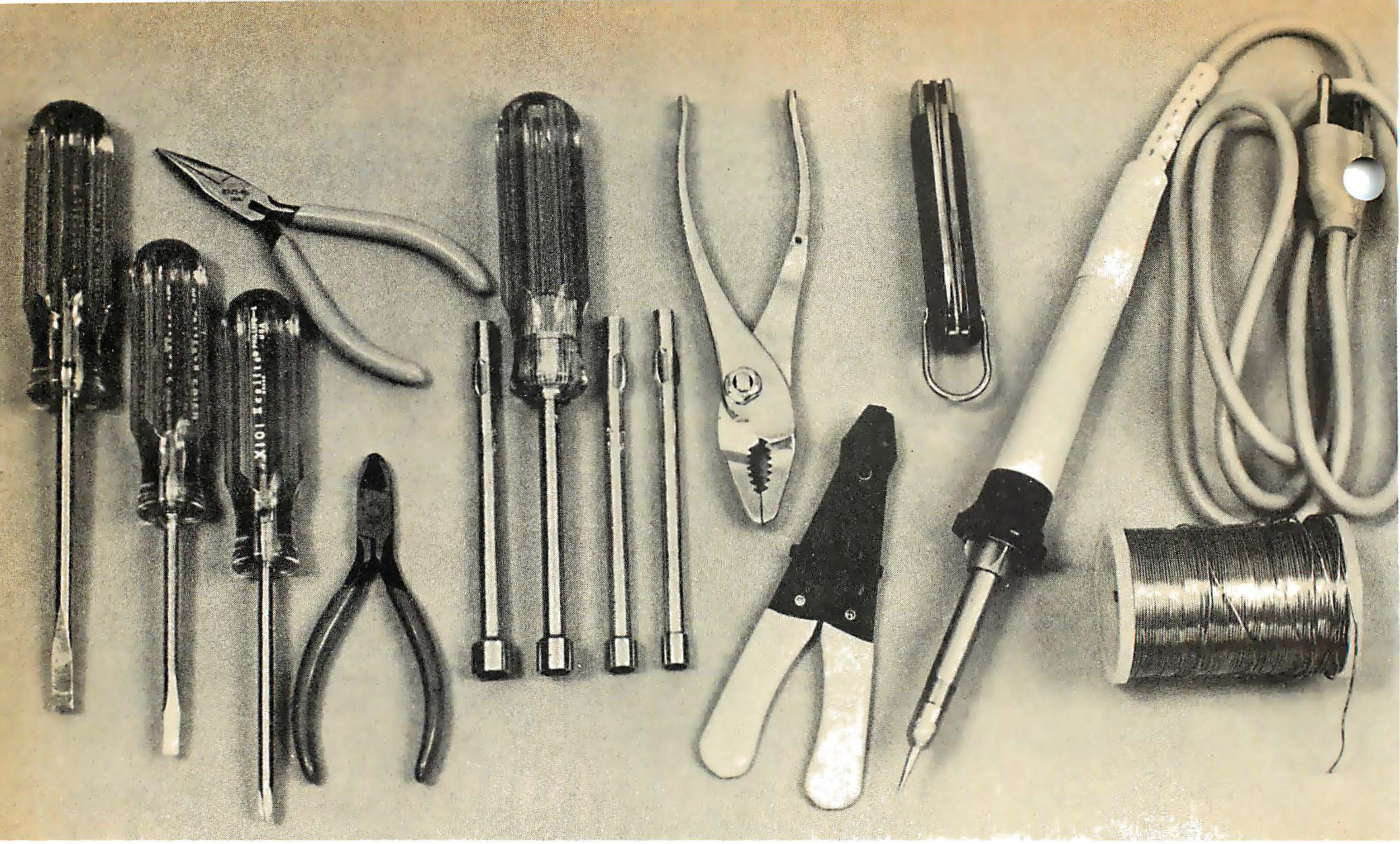
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What's Involved in Kit Building?

A collection of typical tools useful in building a kit. This collection includes several sizes and types of screwdrivers, needle nose pliers, side cutter (diagonals), a set of nut drivers, pliers, wire stripper, knife, soldering iron and solder. A solder removal device, such as a bulb sucker or a mechanical action sucker, is also most useful.

Louis E Frenzel
1588 Oak Ter
St Joseph MI 49085

Most of the personal computing equipment available to the hobbyist today is in kit form. As a result, the field of personal computing as it is now known essentially centers around the building, testing and troubleshooting of computer kits. Many individuals with a "computer hobbyist" approach to the field are electronic types who enjoy kit building and consider their work with the equipment to be the main focus of their interests.

However, many other people would rather concentrate on the programming and application of the equipment. Such individuals may not enjoy or even consider themselves capable of building some of the sophisticated computer kits available. Yet many of these nonhardware types are taking a chance on their being able to successfully learn kit building. They do so simply to be able to have the equipment that is available today. At this point in the development of the personal use computer field, being able to build a kit often means the difference between being able to own a fairly sophisticated computer or not.

There are many benefits to be gained by building a kit. Kit building is something that can be learned and easily mastered even by individuals who do not know and understand electronics. The purpose of this article is to outline the benefits of kit building and to present some basic guidelines and procedures that anyone can learn to successfully

Kit building is something that can be learned and easily mastered even by individuals who do not know and understand electronics . . .

construct a kit. The personal use computer field will continue to remain essentially a kit business for the immediate future. Why not join others in experiencing the benefits that come from this activity?

Benefits of Kit Building

Most inexpensive computer equipment is available in kit form because sometimes this is the fastest and easiest way for a manufacturer to develop and offer the product. This has allowed many small companies to enter the market quickly. Kits have been largely responsible for expediting the growth of hobby and personal computing by allowing young manufacturers to sell more products sooner.

While kits offer benefits to the manufacturer and to the builder overall, the real benefits of kit building go to the builder. Some of the benefits are obvious, but others are more subtle. Let's consider them.

Save money. One of the obvious benefits of purchasing kit equipment is the resulting savings in money. Kits almost always cost less than equivalent wired and tested products simply because the cost of labor is removed. In some cases, the price of a kit can be as low as one half the assembled price. Such savings are significant and have often made the difference between an individual being able to afford a computer or not. The cost savings has further benefited the field by allowing many more individuals to participate. It certainly makes sense to assemble the equipment yourself if you can. For a given upper limit dollar investment, you can afford significantly more equipment if you purchase kits.

Pride of accomplishment. A benefit not as obvious to those who have never built a kit is the sense of achievement that it produces. This is particularly true of large, complex and difficult kits. When an individual successfully assembles a sophisticated kit and makes it work, he or she is rewarded with a real sense of accomplishment. This is a feeling that is hard to describe, but one that becomes obvious when you build your first successful kit.

Fun and enjoyment. This is a do it yourself age. Most people enjoy doing things for themselves if they can. There is a certain amount of enjoyment in tuning your own car, growing your own garden, or paneling your basement. The same is true in the computer field. People want to do it themselves and find enjoyment in it. Kit building as a hobby fulfills this need for fun and involvement. Like other hobbies, kit building is relaxing since you become occupied in an activity that demands your full attention and skill. It takes your mind off other problems and worries.

Learning. One of the most subtle benefits of kit building is learning. Whenever you put a kit together and make it work, you automatically learn more than you realize. The whole process of kit building is educational. This is particularly true for those individuals who are not electronic experts. Beginners quickly learn basic skills such as soldering, identifying electronic components, theory of operation and basic testing and troubleshooting methods. The learning may not be obvious as you are constructing the kit, but it is there and sooner or later you will realize it.

Kits can: save money, give pride of accomplishment, provide fun, enjoyment and learning, and prepare the owner for maintenance.

Lou Frenzel has been an enthusiastic personal computing advocate of the "build it yourself" variety for some time. His personal systems presently include an IMSAI 8080 kit product with 8 K of memory, an evaluation board 6800 system from Motorola with enough additional memory to run Tom Pittman's Tiny BASIC, an ASR 33 Teletype, audio cassette interfaces, serial and parallel interfaces for custom peripherals. One projected application for the computers is to amateur radio, where he aims to use the processors for station control, and processing of message and logging data for his station, W8LJR. Professionally, Lou is Director of Computer Products for the Heath Company, a firm which started the electronics kit business as it is known today.

A "beginner's" kit assumes no knowledge of electronics and is exhaustively documented.

An "experienced builder's" kit assumes some knowledge and familiarity with electronics and as a result is less expensive due to savings in documentation cost.

Preparation for maintenance. Electronic equipment is much easier to service, repair or modify if you are familiar with it. Once computer equipment has been assembled and made operable, it is generally reliable. But should service be required, it will be easier if you know and understand the equipment. Kit building gives you much of that knowledge and familiarity.

These are only a few of the most important benefits of kit building. If you want total involvement from your use of computers, you should participate in as many of the different facets of it as you can. Kit building is one of the best ways of achieving this participation.

Types of Kits

All kits are not equal. There are big kits and little kits, easy kits and complex kits. In addition, there are different types of kits depending on the approach taken by the manufacturer and the intended customer. Before you purchase a kit and attempt to assemble it, it is a good idea to be aware of the types of kits available.

There are two broad, general classifications of electronic kits, those for beginners and those for experienced hardware people. These classifications really represent the extremes of a range of types of kits; but for purposes of discussion such "ideal types" are useful. Kits designed for the beginner are generally simpler and more thoroughly documented. Even an individual who knows nothing about electronics can usually assemble such kits successfully. The assembly, test and troubleshooting instructions are thorough, take nothing for granted and lead the kit builder by the hand through a step by step process of assembly. With such a kit, most people have little or no difficulty in assembling the product and getting it to work regardless of their knowledge and experience. Even though you may not be a beginner, this type of kit is often the best in terms of value because it practically insures hassle free building and a workable end product.

Another type of kit is one designed for the experienced kit builder or electronics expert. Such kits are furnished with a minimum of documentation and assembly instructions. In some cases only a schematic diagram, a printed circuit board layout showing component placement, and a parts list are supplied. To an experienced builder, this is usually sufficient information to assemble the product and get it to work properly. Many of the computer hobby kits available today are of this type. They assume that the builder is familiar with such equipment or it would not be purchased in the first place. Many novices and beginners have discovered this too late. There's nothing wrong with this type of kit because it does produce a useable end product. The problem comes when an inexperienced builder attempts to construct a kit of this kind and makes mistakes due to either lack of knowledge or experience. Such kits are highly desired by the experienced builder because they give him far greater satisfaction and a feeling of more involvement than the simpler kits, and ultimately have a lower cost since "idiot proofing" the documentation is a significant cost item in any kit. Experienced electronic kit builders receive great satisfaction from using their knowledge and experience in such projects. Many even enjoy discovering errors or having to supply missing information. They like to do the research necessary to build a product successfully. What may be a problem and big frustration to some is a real challenge and enjoyment to others.

Qualities of a Good Kit

Just what are the qualities of a good kit? It is desirable to know the elements of a good kit so that when you evaluate a product or compare competitive units, you will choose the best product for you. Here are several things you should look for in choosing a kit product.

Well designed. This is a subjective point yet an important one. A good design is one that works, has proven itself reliable and accomplishes its purpose. Other elements of good design involve the use of modern components and techniques. Good design is difficult to assess if you are not familiar with the specifics of the equipment or the latest technology. However, good product design generally shows up as a good reputation in the field, positive comments from owners, and favorable magazine test reports. If you are a newcomer, read every scrap of literature you can find, talk to people at your local computer club, and keep an open mind!

Good documentation. Just as important as good design is good documentation. This is an absolute necessity for a successful kit. The manufacturer simply must supply sufficient information to build, test and apply the product. Poor documentation usually means the difference between a good kit and a bad kit. A well designed kit can be bad because poor documentation makes it difficult if not impossible to assemble and use. Look for and insist upon good documentation to the level of detail you require.

Quality components. Quality or first grade components are a major part of any

Some Typical Introductory Kits

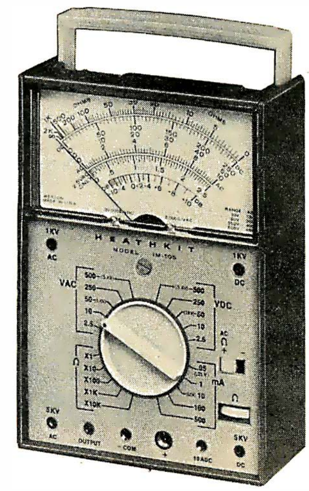
The Heath Company is the oldest and largest manufacturer of kits. For those computer people who are wary of trying a complicated kit, author Frenzel suggests several of his company's products as a means of seeing what it takes to build a kit by trying out the concept on simple items. Each of these items will result in a useful accessory for the computer lab, as well as introducing the builder to the process of building kits.



a. A prototyping breadboard. In computer applications, such a breadboard can be used to temporarily try out a circuit before committing it to permanent form using wires, sockets, Vectorboard and solder or wire wrap. Power supplies at standard logic (+5 V) and typical analog (±12 V) levels aid prototyping with this unit.



b. A laboratory bench power supply. Once built, this instrument is used to simultaneously power logic (+5 V) and provide variable metered analog levels from ±0 to ±20 V.



c. A multimeter. This all around useful test instrument can be built from a kit and later used to measure miscellaneous voltages, current and resistance when diagnosing or using the hardware of a computer and its interfaces.

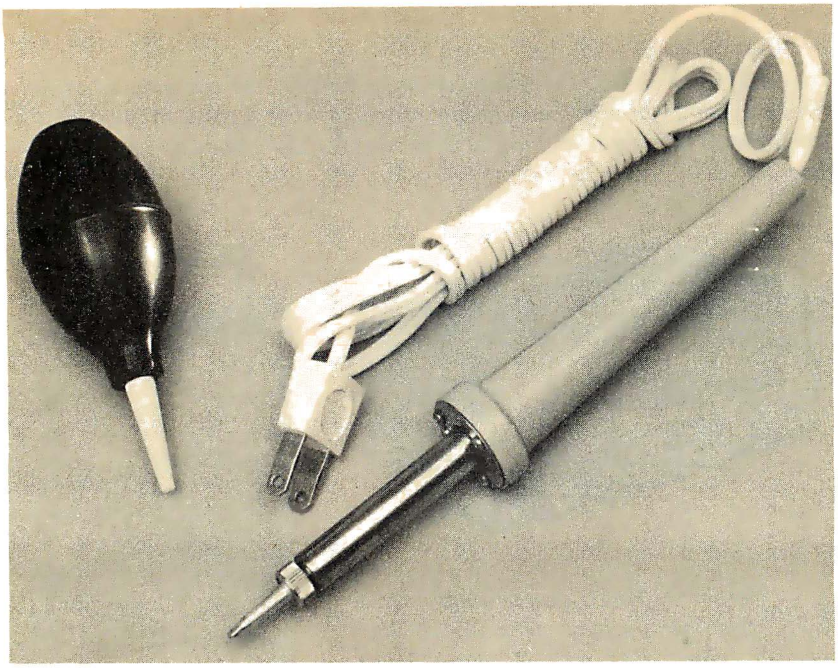
good kit. If a manufacturer uses regular commercial grade components, then the quality is good. Quality components help insure reliability and a minimum of defects and problems in assembly. Kit suppliers can sometimes purchase surplus or degraded components at significant savings. As a result they can pass along major cost savings to you. While lower cost is certainly a significant benefit, it is often offset by the problems encountered by the poor component quality. Unless you are prepared to deal with the limitations and problems brought about by low quality components, it is best to stick with the higher priced but more reliable units using quality parts.

Designed as a kit. Many products are not designed to be kits. Such products are designed first to have specific features and to meet certain performance specifications. The fact that it is to be offered in kit form is often secondary. The designer's main purpose is to achieve a saleable and workable product. Once this has been done, many designers feel that it is only necessary to supply the components in a bag which the customer can assemble. If the product is designed as a kit, the designer is constantly reminded that the product must be easy to assemble and service. For that reason, kit design and thorough documentation is somewhat more difficult and time consuming than designing equipment that will be manufactured. Such products generally come from those manufacturers dedicated to the kit business.

Manufacturer support. A good kit manufacturer is one that supplies plenty of service and support. A customer can make wiring errors, receive a defective component or simply have difficulty in interpreting the documentation. The customer must have some way of dealing with these problems if he or she is to be satisfied with the product and complete its assembly. Always look for a kit manufacturer which has a significant amount of backup. This means the manufacturer will answer your letters and telephone calls regarding problems. In addition, the manufacturer should offer complete service and repair facilitiies at reasonable prices. Also check the warranty. Before you purchase a kit, be sure that you satisfy your own requirements with regard to the support and service available.

These are the main qualities of a good kit. Before spending hundreds or even thousands of dollars on computer equipment, investigate these points carefully. Your satisfaction with the products will be greater if you do.

A good design is one that works, has proven itself reliable, and accomplishes its purpose.



Key 1: A low wattage soldering iron is a must for building computer kits (or any kit with delicate printed circuit runs). Here is a typical low wattage iron with a small tip, along with a suction bulb device which can be used to remove solder if necessary.

Photo supplied by the Heath Company

Read test reports on the products that you are considering. Ask friends, associates and fellow club members for their opinions on the product. Often the experiences of others can help you decide. Also get as much information from the manufacturer as you can. If the data sheets and catalogs supplied are insufficient, write for further information. A reputable manufacturer will answer your specific questions and provide additional information as required.

One of the best ways to size up a product is to purchase the documentation for the kit. Most manufacturers will allow you to purchase the assembly and operation manuals. This will give you full details on the product and will give you an advanced look at the assembly instructions and other information. If you're serious about a product, this is a small investment to make to insure that you obtain a good product.

Building the Kit

Here are some tips, based on experience, that can help you build kits successfully even if you are a beginner:

Practice first. Before you wade into a $1000 computer kit, perhaps you should test or improve your skills first on a simple, low cost kit. This is particularly true if you are a novice. If you have never assembled a kit before, start out with a small, easy to build project first. You will learn a lot by assembling this simple project first, and you will get a feel for what kit building is all about.

There are a wide variety of simple low cost kits available. Many accessories and pieces of test equipment fall into this category. Try to choose a project that will be useful to you when you get to the computer kit, or in some other way. A good example of equipment that could be of value to you when working with computers is a volt ohmmeter or a power supply. Both of these items are relatively easy to build and you will find much use for them later when working with your computer system.

Obtain the proper tools. You will need a variety of tools to build a kit successfully. There is nothing more aggravating than to come to a point in the assembly process where you do not have the tools needed. While most kits can be assembled with common tools, you should provide yourself with a minimum set prior to building your kit. It will make the kit building process go faster and easier. Here is a list of the most common tools you will need:

1. screwdrivers of several sizes: blade and Phillips types
2. needle nose pliers
3. side cutters
4. nut drivers (0.25 inch is the most useful.)
5. pliers
6. wire strippers
7. knife
8. soldering iron
9. solder
10. solder removal device

Learn to solder. The most important skill required to build a kit is soldering. The majority of computer equipment is constructed by attaching electronic components to printed circuit boards. The circuit boards are then interconnected to one another through other printed circuit boards, connectors and cables. Solder is the common bonding element in all cases. You simply must learn to solder if the kit is to work properly.

Soldering is the process of melting an alloy of tin and lead known as solder, wetting the component leads with the hot molten solder, then allowing it to cool and provide a permanent electrical interconnection. The components to be joined are brought together physically and the joint made mechanically secure. Then a soldering iron is touched to the joint so that the component leads are heated. Once the joint is hot enough, solder is applied and allowed to flow over the connection. Then the heat is removed and the solder is allowed to harden. The result is an excellent mechanical and electrical connection.

To solder properly, you must have the right equipment. Primarily this means a soldering iron and solder. For most electronic construction, a small, low wattage, hand held pencil type soldering iron should be used. One with a wattage rating of 25 to 40 watts is best. This will provide more than sufficient heat but at the same time is low enough in wattage to prevent damage to electronic components. The soldering iron should also have a small, fine tip so that solder can be successfully applied to the very small connection pads on most computer circuit boards.

The type of solder used is also important. Many kits are supplied with the proper solder. If solder is supplied, use it. If you buy your own, be sure to purchase quality electronic grade solder. The best is a 60-40 rosin core solder. The 60-40 refers to the percentages of tin and lead respectively in the solder. The rosin core means that the solder contains a cleaning element that helps to remove the oxidation from the connections when heat is applied. (Do not use acid core solder which can destroy electronic components. It will literally digest your computer.)

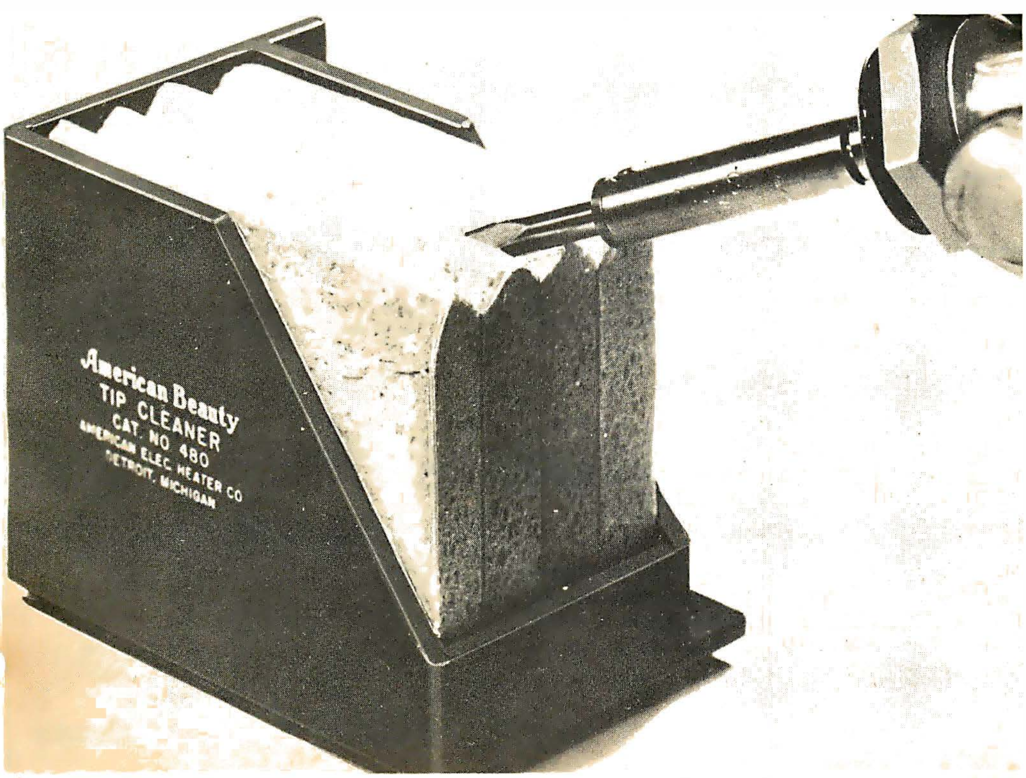
The size of the solder is also important. For the tiny circuit board work found in most computer products, a thin solder is best as it is easier to control the rate of flow. Solder smaller than 0.032 inches in diameter is best. This will prevent excess solder from being applied and will reduce the possibility of making solder bridges.

Next you should develop your soldering skills. The best way to do this is to practice. The proper procedure is to first physically connect the components. Usually this involves bending the leads of the component and mounting it on a printed circuit board. The soldering iron is then used to heat the junction of the component lead and the foil on the printed circuit board. It takes only several seconds for the joint to become hot enough to melt solder. Solder is then applied to the junction and allowed to flow over the leads and copper foil. The solder and iron are removed and the connection is allowed to cool and harden.

While the procedure sounds simple, it is a bit subtle. The subtlety has to do with the amount of time you heat the junction prior to applying solder and the amount of time the iron is left on the joint after solder is removed. If you apply too much heat in the beginning you can damage the component or cause the copper foil on the printed circuit board to peel off. Yet if you do not apply enough heat, the joint will not become sufficiently hot to melt the solder properly. If the solder is not melted thoroughly it will cause a so called "cold solder" joint. These are conditions where proper bonding does not take place. The amount of time that the heat is applied is a balance between that which prevents damage and that which

Simple points: Practice first, obtain proper tools, learn how to solder, learn how to unsolder, and if all else fails, read the directions.

One of the best ways to size up a computer product is to purchase the documentation (or borrow it from a friend). This is true whether the product is in kit form or not. (A corollary is the thought that good looking and complete documentation is an excellent sales tool for the manufacturer.)



Key 2: One key to good soldering is a clean soldering tip. There are several different brands of wet sponges like this one, which can be used to clean the tip during use. Many of these products are treated with special chemicals to help improve the cleaning properties.

Photo supplied by the Heath Company

allows the solder to melt and flow as it should. The skill and timing in this operation comes only from practice.

Learn unsoldering. Another skill practically as important as soldering is unsoldering. It is often necessary to remove a component from a printed circuit board. The component may become defective and need replacing. Or you may have discovered that you connected the component incorrectly. If you learn the technique of unsoldering, the component can be removed without damaging it or the printed circuit board.

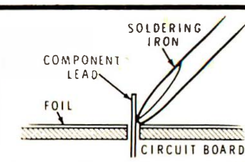
Unsoldering is best accomplished by removing the solder on the connection. Do not attempt to remove a component by simply reheating the connection and prying the component from the printed circuit board. Damage will usually result. Although it takes a little more time and care, removal of the solder first will insure that you do not damage either the component or the printed circuit board.

Solder can be removed from the connection by first heating the connection with your soldering iron and and then using a suction bulb. This is a device designed to pull the solder from the connection by a vacuum created in a rubber bulb. A plunger type device known as a solder sucker can also be used.

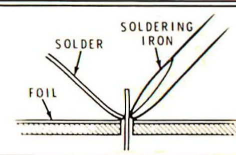
It may take several applications of the tool to remove all of the solder. Get as much off the connection as you can. Then use a knife or needle nose pliers to carefully break the component lead loose.

Another method of removing solder from a connection is to use a wire braid coated with rosin. The braided wire is coarse and

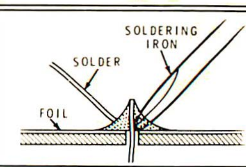
1. Place the soldering iron tip against both the lead and the circuit board foil. Heat both for 2 or 3 seconds.



2. Then apply solder to the other side of the connection. IMPORTANT: Let the heated lead and the circuit board foil melt the solder.



3. As the solder begins to melt, allow it to flow around the connection. Then remove the solder and the iron and let the connection cool.



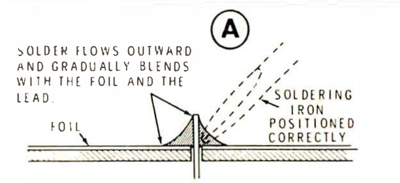
4. Hold the lead with one hand while you cut off the excess lead length close to the connection. This will keep you from being hit in the eye by the flying lead.

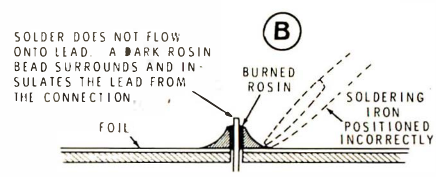
Key 3: Use proper soldering technique. This set of illustrations provided from the Heath Company documentation of kits illustrates proper soldering technique when assembling circuit boards. As noted at the bottom, it is important to heat both the component lead and the printed circuit board contact. If either is missed, then a bad joint as at B or C could result.

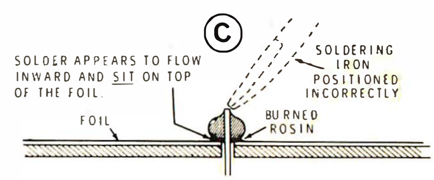
Be sure the solder made a good electrical connection. When both the lead and the circuit board foil are heated at the same time, the solder will flow onto the lead and the foil evenly. See Illustration A. The solder will then make a good electrical connection between the lead and the foil.

When the lead is not heated sufficiently, the solder will not flow onto the lead as shown at B. Reheat the connection and, if necessary, apply a small amount of additional solder to obtain a good connection as shown at A.

When the foil is not heated sufficiently, the solder will blob on the circuit board as shown at C. Reheat the connection and, if necessary, apply a small amount of additional solder to obtain a good connection as shown at A.







can soak up a lot of solder. The rosin cleans the braid and the connection and encourages the capillary action that literally slurps the solder off the connection. To use the braid you simply place it on the connection and heat it with the soldering iron. The solder will flow up into the braid leaving the connection clean and open. Again, several applications may be necessary to remove all of the solder. Solder removal braid is available at most stores selling soldering irons and related equipment. It is extremely effective and will save you much time and possibly some expensive components and printed circuit boards.

Follow directions. It seems almost ridiculous to point this out, but one of the most common faults of kit builders is not following the assembly instructions. The assembly instructions have usually been tested to insure that they work. If you use a different assembly sequence or fail to note some of the special instructions, you are most likely to make a mistake. Even though you may be an experienced kit builder, sometimes there are subtleties in the assembly process that make it absolutely essential that you follow the given directions.

Another precaution is to look for any errata sheets or correction notices *before* you begin the assembly. Some errata sheets are included randomly or at the end of the supplied documentation. Don't take chances; catch the errors in the documentation first to avoid mistakes.

Don't ruin your investment by assuming that you can do it by yourself. Protect your investment and follow the instructions. Remember the old saying, "If all else fails, read the instruction manual," is true.

Take your time. When building a kit, take your time. The faster you go the more likely you are to make a mistake. Most people who purchase kits are anxious to put them together and use them. This is only human and certainly understandable. But unless you have patience and take your time to follow the instructions and do quality work, your

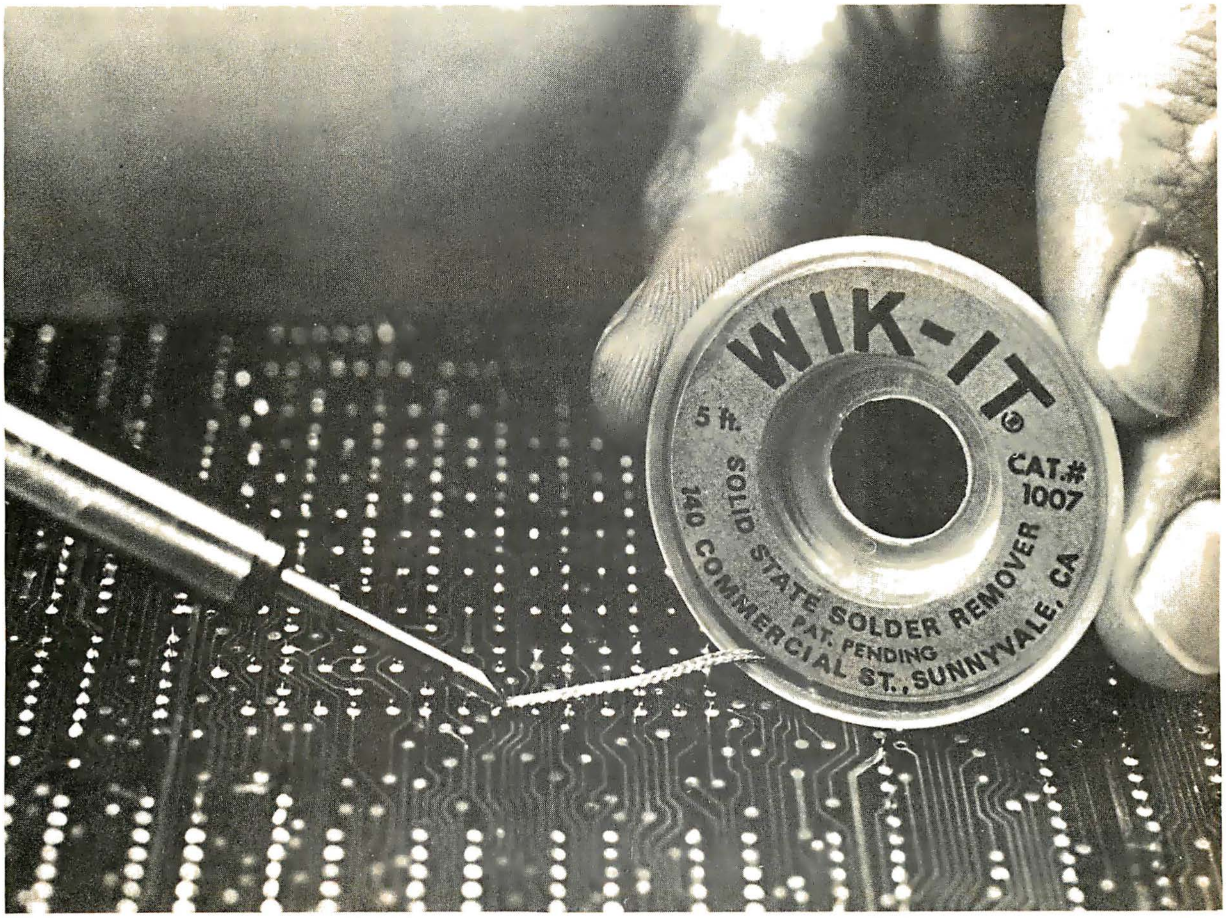
Use of sockets remains a highly recommended practice — but use quality sockets by all means.

Key 4: If you make a mistake, fix it. To remove solder, use a bulb sucker (see key 1), a mechanical solder sucker tool (a), or a solder removal braid (b).

(a) Photo supplied by the Heath Company



(b) Photo courtesy of Wik-It

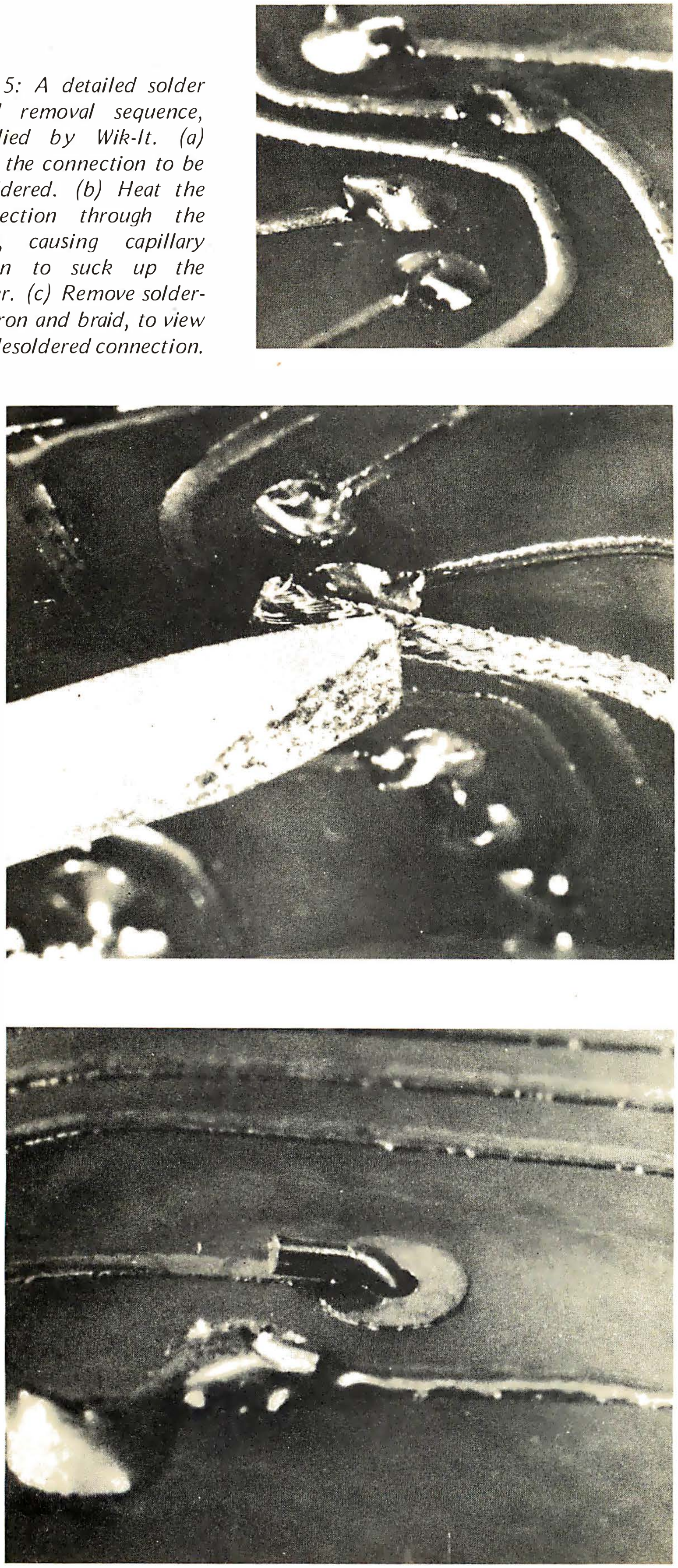


Key 5: A detailed solder braid removal sequence, supplied by Wik-It. (a) Find the connection to be desoldered. (b) Heat the connection through the braid, causing capillary action to suck up the solder. (c) Remove soldering iron and braid, to view the desoldered connection.

(a)

(b)

(c)



chance of achieving a successful build are much lower. A better end product will result if you take care and time.

Part of the concept of taking your time is to spread the kit building process out over a long period. It is a lot better to have eight one hour or four two hour kit building sessions than it is to have a single eight hour session. The longer the kit building session, the more mistakes you are likely to make. When you find yourself getting tired, losing interest, or attempting to short cut the instructions, stop. Go back to building when you have had a chance to rest.

While it's good to take your time in building a kit, just keep in mind that most kits come with a limited time warranty. Thirty and ninety day warranties are typical, so it is highly desirable that you assemble the kit in less than that time. If you discover any defective parts or other problems, you can get them replaced within the warranty period. Take your time, but don't lose the benefit of any warranty that you may receive.

Ask questions. As you're building a kit you may have questions about the assembly. If the instructions are not clear or problems arise, don't guess. Don't take anything for granted. Attempt to answer the question yourself, of course. Study the directions more carefully. Ask a friend who has built a similar product. Call or write the manufacturer to be sure of what you're supposed to do before you go on. You can save a lot of time, money, grief and dissatisfaction if you get answers to questions before going ahead with what may be an incorrect decision.

Use sockets. Many electronic kits do not supply sockets for the various components. Transistors, diodes and integrated circuits are usually soldered directly to the printed circuit board. Some of the more expensive and delicate components may use sockets. While sockets may not be supplied, it is generally a good idea to add them yourself. The sockets will allow you to remove components for troubleshooting purposes or to replace them if they become defective. The socket will add a little extra cost to your kit, but the advantages are worth it. The ease with which a product can be serviced when all of the integrated circuits are in sockets is excellent. It is one investment that you may question in the beginning but will certainly find worthwhile later should you have difficulty. If you choose to use sockets, however, be sure to use high quality *new* sockets, preferably with gold or other nontarnishing finish on the contacts.

Provide yourself with reference resources.

Many manufacturers supply all the information needed to construct the kit successfully. Additional information simply is not necessary. But there are some kits that require you to have additional information. For example, it may be necessary for you to know the pinouts or theory of operation of the various TTL or MOS integrated circuits used in the kit. Because of this, it is a good idea to provide yourself with a reference library of books, catalogs, data sheets and any other information you can get your hands on. You will also find general textbooks and application notes from the integrated circuit manufacturers to be helpful. When you run into trouble or have questions, your references can provide the answers. It is an excellent investment that you should make at the time that you purchase your kit.

Two of the most important references you should have are the *Texas Instruments TTL Data Book* or its equivalent and the catalog or data sheets from the manufacturer of the microprocessor used. Adam Osborne's series of microprocessor books are particularly good and will also make excellent background reference sources.

Be careful with components. Most electronic components are small and delicate. They can be easily damaged physically and most can certainly be destroyed by excessive heat. Diodes, polarized capacitors and most integrated circuits can be put in backwards which would cause improper operation and possible electrical damage. Integrated circuit pins can also be bent and broken off very easily. Be very careful with every component as you install or solder it.

Another important precaution concerns the installation of MOS integrated circuits. These devices can be destroyed by static electricity. A static charge can be transferred to a MOS device by your hand or the soldering iron. Most MOS devices are supplied mounted in protective foam to keep the pins shorted. Leave the devices in this foam until you are ready to install them. When you do, be sure you ground yourself or remove any static charge before you pick up the device. If you use sockets, the MOS damage from static charges can be greatly reduced. Any charge from the soldering iron will be dissipated in mounting the sockets, not installing the integrated circuits. Further, when installing the integrated circuit in the socket, you can short all the leads together by pressing the board and socket against conductive foam.

All of the above recommendations and precautions are obvious for the most part. It's easy to read them and agree with them, but if you are to assemble your kit successfully, you absolutely must follow them. It's a small price to pay for protecting your investment.

Provide yourself with a library of reference information about computers, integrated circuit logic data, etc. It will prove to be one of the most valuable pieces of "equipment" in your personal computing endeavors.

What to Do If You Have Trouble

Whenever you purchase a kit you should prepare yourself for the fact that you may make a wiring mistake or encounter a defective component. If you plan for this in the beginning you will not be surprised if it happens. In most cases you will find that it is not a serious problem. Instead it is simply an inconvenience to overcome. If you approach it with the right attitude, you will not be dissatisfied with your kit. Here are some tips on what to do if you experience difficulty.

When you finish building the kit, follow the test, checkout and troubleshooting instructions given by the manufacturer. The quality of this information varies from one manufacturer to another. Some supply no information while others furnish detailed troubleshooting charts. Use whatever information is available to you first before going on with the recommendations given below.

Question the problem. The first thing to ask yourself: Is the trouble you experienced really a problem? It may indeed be, but it may also be that you are using the equipment improperly. The controls may have been set incorrectly or you may be wrongly interpreting the results. The solution to this is to read the instruction manual carefully to be sure that you are doing things properly. In computers, as in flying, cockpit problems or pilot errors are a typical source of trouble. The hardware may be good, but the operator may be defective. Even in simple kits this is a very common problem. Due to the complexity of computers, no kit will be totally immune from this problem.

Check your assembly. Once you have eliminated operator error as the trouble, you can assume that you have a hardware problem. The first suspect is assembly errors. Go back and double check your assembly. This is time consuming but it can often turn up the problem. A good way to do it is to have a friend help you. Often by working with someone else you can find the problem

Be sure to remember the motto of a certain very large computer company: THINK. The application of computers as general purpose problem solvers requires thought on the part of the user, whether the computer is a kit or a traditional high priced product. The only computers which have any hope of being totally "idiot proof" are those which have had the thought requirements distilled into a well designed application program in products such as a hand calculator, a microwave oven controller, a "turn key" application system or any situation where the programming is supplied in a packaged solution to a problem.

that you may have overlooked yourself. A common mistake is poor solder connections. It may be difficult to spot one bad solder connection among thousands, and even a bad solder joint sometimes looks good. As a result, the first step should be to resolder each and every connection in the kit. Again this is tedious but will often solve the problem. To do this, simply touch the soldering iron to each solder connection briefly to remelt the solder. If you see a wisp of smoke come out of the connection, it may indicate that the rosin in the joint was not sufficiently melted thereby causing a poor connection. The joint may have been a cold solder joint where no electrical continuity existed at all. Simply reheating the connection made it good.

As you are resoldering the connections, look for solder bridges. This is a thin trace of solder that is accidently drawn between adjacent pads on the circuit board. The solder bridge causes a short. These bridges are usually eliminated as each solder connection is reheated. But they may not be. As you are resoldering each connection, look carefully at adjacent pins to be sure that shorts do not exist. Some solder bridges are so fine that they are difficult to find. Use a magnifying glass and strong light to help. As you go through a complete circuit board you may discover connections that you forgot to solder or components that did not get installed properly. Simply resoldering all the connections is an excellent way to recheck your assembly since it methodically covers all points.

Once you have double checked your soldering and assembly, again test the equipment. Many times the problem will be solved and proper operation will result. If the difficulty still exists, the problem may be a defective component. Unless you have had specific experience in troubleshooting electronic and digital equipment, locating a defective component can be difficult. For that reason, it is best to call for help.

Seek help. The first step is to ask a friend or the manufacturer for help. You may be able to find a friend who has built a similar piece of equipment or who has experience in troubleshooting. Don't hesitate to call or write the manufacturer for help. It is the manufacturer's responsibility to help you get the kit working properly.

Another alternative is to seek help from your local computer store. Most store owners will be familiar with common problems and may have just the advice, information or help you need.

Before you ask for help, however, it is best to isolate the problem yourself if you can. Write down all of the symptoms. Make some tests yourself to try to determine what is happening or not happening. If the processor runs at all, run some simple diagnostic programs to attempt to isolate the problem. Try to obtain as much information as possible before you ask for help. The more information that you supply the better the quality of the help that you will receive. For example, one of the things that you can do is measure the power supply voltages. Often the equipment is not working simply because it is not receiving power. Use a voltmeter to check power supply voltage at each of the printed circuit boards in the equipment. If an oscilloscope is available, check for the presence of clock pulses.

Once you have accumulated as much information as possible, write a letter or make a phone call to the manufacturer. Continue this process until the trouble is located. If all else fails, return the kit to the manufacturer or your local computer store for repair. Above all, don't give up. The real fun begins when you get your computer running.

Kit Versus Wired Products: Your Decision

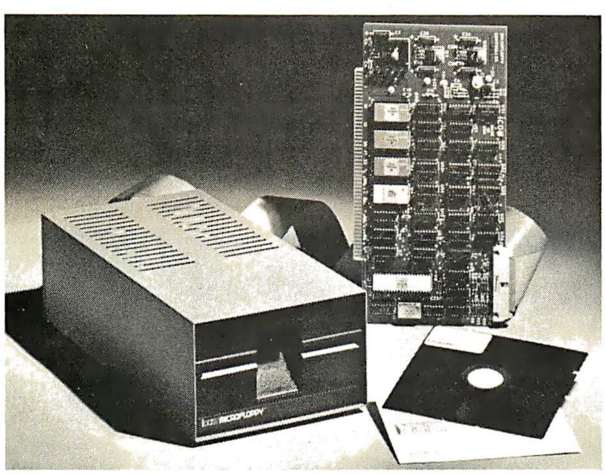
Kit building is fun, challenging and satisfying. It is educational, and you can save a lot of money. Most people who have built kits successfully highly recommend it. Yet some computer hobbyists simply do not want to spend the time or become involved with kit building. They want to concentrate on programming and applications. It is probably best that these individuals buy wired and tested units. Although this reduces the number of products available, it does eliminate the potential problems associated with kit building. It also eliminates the benefits.

Before you decide to buy a wired product, you should also consider having a friend or other individual build the kit for you. Often you can locate someone who is willing to build a kit for a price far lower than you would pay for an assembled unit from the manufacturer. I have heard of several examples where individuals have assembled kits for others simply to be able to have the experience of building and using the kit themselves for a period of time. There are a number of small companies who are in business to build kits for individuals. The prices are usually less than the assembled and tested units available from the manufacturer.

Even though you may have shied away from building a kit, try it. You may find that it is easier and more fun than you suspected.■



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Continued from page 14

perhaps the extreme case for shipment of BYTE magazines to foreign subscribers. Not satisfied with waiting three months or so for the very current information we put out in BYTE each month, he started immediately to search for alternatives.

His first urge was to import BYTEs in sufficient quantity to sell to his neighbors in the Sydney area, thereby assuring (so the theory went) that he got them on a timely basis by way of a bulk shipment. With that in mind, he figured that he'd send them air freight to his shop, then distribute them. Nice theory, but, in bulk it cost US $1.50 or more to ship each magazine by air -- so his bulk shipments ended up going on the same boats which carry the surface mail. (It costs nearly US $6 to send just one copy by air mail!) So much for that theory. After taking a bulk shipment of BYTE each month for several months, John hit upon another solution to the problem: Maybe he could talk BYTE into printing locally for distribution in Australia. Shortly after that brainstorm struck, we got our first long distance phone call from John Bannister.

Phone calls from Australia are most interesting. You'd expect that a certain decay in quality would occur as the distance increases. But much to our surprise, the phone conversations with John, whether by cable, radio or satellite, often came through with a quality perhaps half an order of magnitude better than a simple transcontinental conversation with an advertiser in California! Of course, for such calls, either one party or the other is bound to be half asleep, for the time differential is 11 hours between EST and the time zone which encompasses Sydney. At any rate, the first phone call was to explore the possibility of setting up a new Australian publishing house with John as the principal, whose purpose would be to print an Australian English language version of BYTE. Thus began a series of long distance negotiations, proposals, Telex messages and phone calls concerning the arrangements. Now that all the negotiating and arrangements have been crystalized into a signed contract, we can announce what has transpired.

Beginning with the January 1977 issue of BYTE magazine, two new editions will be published for readers in the more technologically sophisticated areas of Southeast Asia. One edition, in English, will be printed and distributed to subscribers in Australia, New Zealand, Singapore, Hong Kong, the Philippines and other countries where readers of English are interested. A second Asian edition will be translated into Japanese and distributed in Japan. The editorial content of both new editions will be identical (English edition) or identical semantically if different in detail (Japanese edition). For the first issues, the advertising copy will also be identical; but John's office in Sydney and his agent in Tokyo will solicit local advertising for these editions, while preserving the option for our US advertisers to reach these foreign markets.

Technologically, the arrangement is fairly

Articles Policy

BYTE is continually seeking quality manuscripts written by individuals who are applying personal systems, or who have knowledge which will prove useful to our readers. Manuscripts should have double spaced typewritten texts with wide margins. Numbering sequences should be maintained separately for figures, tables, photos and listings. Figures and tables should be provided on separate sheets of paper. Photos of technical subjects should be taken with uniform lighting, sharp focus and should be supplied in the form of clear glossy black and white or color prints (if you do not have access to quality photography, items to be photographed can be shipped to us in many cases). Computer listings should be supplied using the darkest ribbons possible on new (not recycled) blank white computer forms or bond paper. Where possible, we would like authors to supply a short statement about their background and experience.

Articles which are accepted are typically acknowledged with a binder check 4 to 8 weeks after receipt. Honorariums for articles are based upon the technical quality and suitability for BYTE's readership and are typically $25 to $50 per typeset magazine page. We recommend that authors record their name and address information redundantly on materials submitted, and that a return envelope with postage be supplied in the event the article is not accepted. ■



A BYTE family portrait, circa December 1976. Clockwise from top left are Manfred Peschke, Virginia Peschke, John Bannister and Carl Helmers. (Note: the reader probably suspects that all those impressive looking books in the background are the world's greatest collection of computer tomes. While they do indeed look impressive, they'd really only impress a farmer since they contain the genealogical records and trivia of the Guernsey cow breed.)

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John Bannister (left) and Carl Helmers discussing the problems of translating BYTE into Japanese, while perusing the Japanese edition of Scientific American, *December 1976. It turns out that translators do some interesting things. For example, in the translated version of an article by an author with a name of, for example, "Lane," the initials stay in Roman characters, but the surname — since it has a generic equivalent in Japanese script — is translated. But if the surname has no immediately identifiable generic root or equivalent, it remains in English spelling as do technical terms with no direct equivalent.*

simple. At the time we give the final OK to the negatives from which BYTE is printed each month, our printer, The George Banta Company of Menasha WI, will make duplicate copies of all the negatives, and send them to Sydney where John will modify the book to fit the local edition. Eventually this will include local advertising, local club and newsletter information, and possibly putting in new product information and related items of interest to local readers. The bulk of the material in the magazine will, however, remain identical to the US edition.

All our Australian, Japanese and Asian subscribers will be given the option of converting their subscriptions to the local edition which, due to its simultaneous publication, will be up to date as opposed to three months behind due to shipping delay.

Once it became apparent that we would be able to get together on this venture, John made the trip from Sydney to Peterborough NH via Lost Angeles. I call it Lost Angeles because the airline on which he was traveling managed to lose his luggage in the transfer. Arriving at Logan Airport, Boston (after neglecting to tell anybody what flight he was coming on), he was met by Debra "Sherlock" Boudrieau of BYTE, who in a feat of deductive reasoning and investigation, managed to pinpoint the flight and John Bannister, using only his one statement, "I'll be there at 8:30 tomorrow morning." As recounted later, it was a simple deduction: There was only one transcontinental flight out of Los Angeles which arrived at Logan at 8:30 AM, and an Australian newly arrived is easy to spot: After an elapsed travel time of 22 hours with essentially no sleep, watch for the only person who is walking in a daze.

After initial greetings on arrival in Peterborough, John sacked out for about 15 hours, after which we began an intensive series of conferences on the details of publishing remotely, how to arrange shipment of the negatives, timing the monthly operation, etc. After a busy two days, I picked up John at midnight on December 1, and we spent the wee hours at my home and laboratory discussing things and comparing notes on the problems of computer enthusiasts in our respective countries. After I dropped him off back at the motel around 4 AM, we all showed up at the BYTE offices and took the pictures accompanying this editorial. Then, with the contract signed, Virginia and Manfred Peschke and John went to New York (by way of Boston) for a visit to *Scientific American* (see box) and some of the fabled surplus outlets which are reputed to still exist in that city. Manfred and Virginia finally saw John off to Australia from New York and returned to Peterborough that weekend.

One of the details of the Australian arrangement is a surprise and delight to Deborah Luhrs, who has been with BYTE nearly from the beginning. In order to assure a bit of experience, as far as handling subscriber orders and managing an office is

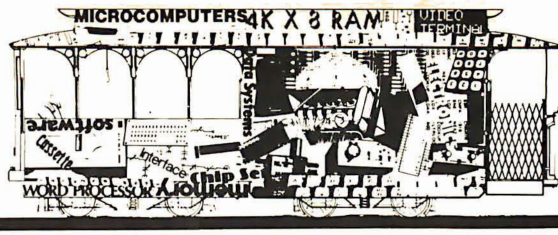
A Note of Thanks to *Scientific American*

We at BYTE wish to thank David Trussell of Scientific American *for taking time out of a busy schedule to meet with Virginia and Manfred Peschke and John Bannister of BYTE to discuss some of the problems and pitfalls of publishing foreign language editions of magazines. With the Japanese language edition of BYTE we begin our first such version in translation, and it proved quite helpful to us to have a bit of informal and friendly advice from people experienced in that endeavor.*

We also learned that Scientific American, *which is printed on extremely high quality paper, has lately been having trouble procuring supplies. The paper is necessary to achieve good reproduction of the color images which are so characteristic of their product. Who could possibly be eating up all the good quality paper? It turns out that there is a hot competition between* Scientific American, Oui *and* Penthouse *to see who can buy all the special paper. This quality magazine is being skinned alive!*

concerned, John thought it a good idea to take up a suggestion which Virginia made: that Debbie should travel to Australia for a few months to help set up the office of the new firm, BYTE Publications [Austr/Japan] Pty Ltd. Although Debbie left today (December 6 1976) as this editorial is being written, she still doesn't quite believe that it's all really happening!

Who is John Bannister, our new "Affiliate Publisher — Southeast Asian Editions"? John is a man of considerable experience in the Australian electronics industry, in the Sydney area. He became interested in small scale data processing systems following Don Lancaster's original TV typewriter articles in *Radio Electronics* and the later articles by Jonathan Titus and company on the Mark-8 processor in that same publication. His assistant in business operations (bookkeeping and moral support department) is his wife Pamela, and he's well aware of the possibilities for using personal computers in the education of his two preschool age children. He's convinced (as are we) that it is just a matter of time until the revolution of personal computing we've seen in this country finally reaches his own country and Japan — to say nothing of the other technologically oriented countries of the world.■



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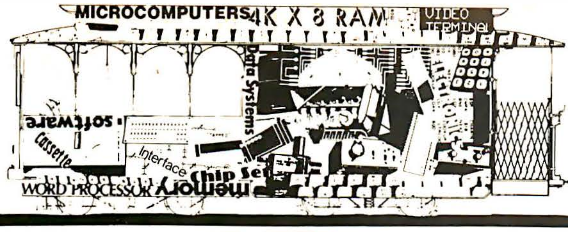
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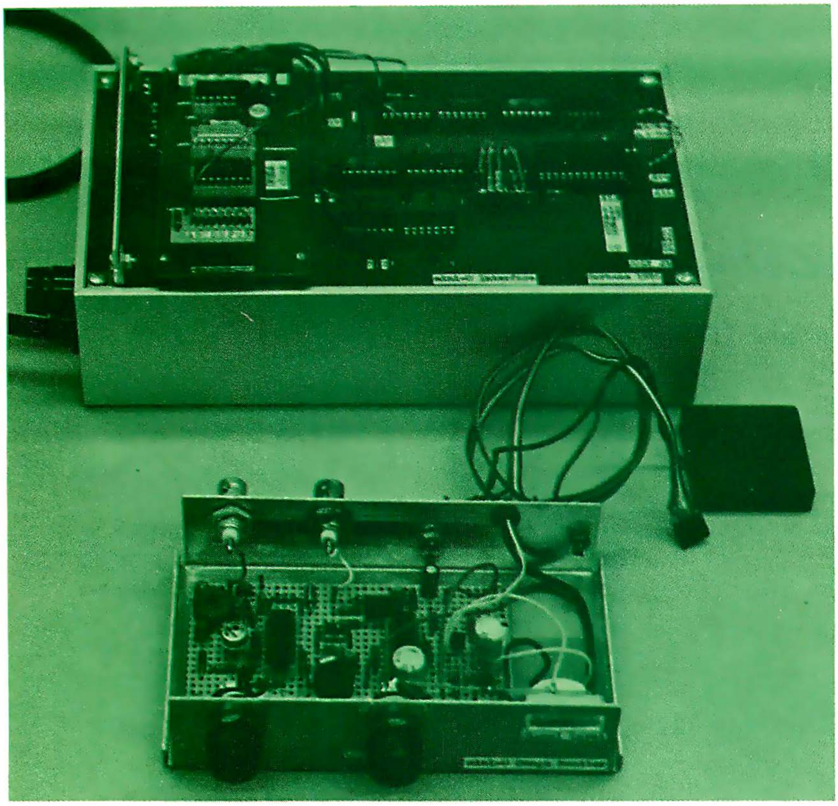
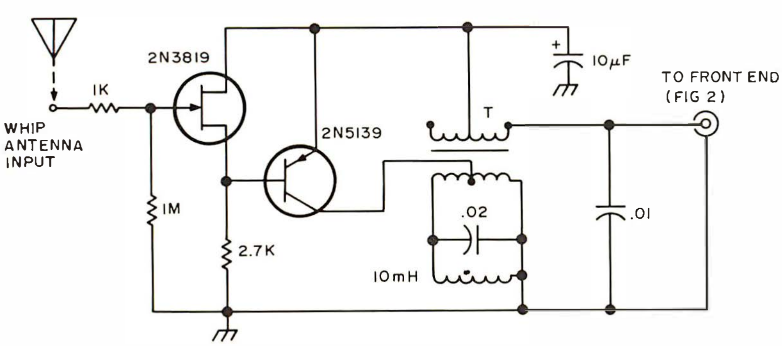


Photo 1: Mini-O microcomputer interface, with the radio frequency front end. The RF front end (in the foreground) is essentially a receiver for 10 kHz radio signals broadcast by Omega transmitters widely spaced around our planet. The device was built in prototype form using perforated board and sockets, as seen here. The microcomputer interface (to a JOLT system) is via the mounted plug at the right of the interface box (rear unit in photograph).



Antennas

The receiver is designed to use an E-field short whip or wire antenna of random length. This type of antenna is often called an "E-field" antenna because it responds to the electric field component of the radio signal. A 20 cm wire will do in many cases if the antenna is mounted in the clear. A 10 meter length wire works well in cases where there is not a lot of local 60 Hz harmonic interference. Unfortunately, the Omega System's 10.2 kHz is exactly the 170th harmonic of 60 Hz and urban laboratory monitors sometimes have problems with bursts of 60 Hz interference from high power SCR-TRIAC controls or rotating electrical machinery. The boat owner or aviation buff usually doesn't have problems with AC line interference and a short whip mounted vertically will often suffice for the antenna.

Preamplifier

The preamplifier of figure 1 is constructed in a small weatherproof box with a tight feedthrough insulator or fitting right at the antenna and a coaxial cable lead-in for the signal back to the receiver (see photo 1). The coax supplies both power to the preamp and a preamplified Omega signal back to the front end module. The circuit is not critical but should be adjusted for a broadband peak at about 10.2 kHz by minor changes in the 0.02 μF capacitor across the inductor. Tapping down on the 600 ohm line output transformer improves the Q of this simple bandpass filter circuit.

Figure 1: Mini-O antenna preamplifier, 10.2 kHz. This preamplifier is shown as constructed in one version in photo 4. The 2N5139 transistor must be selected for a high β. Power for this preamp is sent up the coaxial cable from the front end unit, thus sharing the same wire with the signal. The transformer, T, is a 600 ohm center tapped to 600 ohm center tapped line to line transformer, a Mouser 80TM016 or 80TM009 part number in electronics catalogs. The Q factor for this amplifier is 2, with a gain of 20 dB at 10.2 kHz.

Receiver Details

Omega Navigation is a method of determining where your boat or plane is currently located, anywhere on the globe. It is a "free" method of navigation to a certain extent, since it is sent out by the cooperating nations via radio transmissions for shipping and defense traffic, but is available to any technological hitchhiker willing and able to build the proper interface. (Free in this instance is defined to mean the accounting for each person's share of the tax cost is so diffuse it can't be traced.)

In this month's installment, Ralph W Burhans continues the Omega information with the description of the detailed function and circuitry of an Omega navigation receiver which can play with any microprocessor system possessing an 8 bit input port. [The Mini-O Omega receiver design is intended for an experienced amateur electronics person, and to the best of our knowledge is not *yet* available in kit form for the novice.] *How do you use it once it's built? The details of the software will have to wait until the third and final part of this series, by Richard J Salter, which will appear in the next BYTE.*

ping down on the 600 ohm line output transformer improves the Q of this simple bandpass filter circuit.

The preamplifier has an input impedance of 1 megohm with a 1 k ohm series resistor as a current limiter for gross interference such as from nearby lightning discharges. We have yet to burn out a 2N3819 JFET in these front ends but have had trouble with similar MOSFET input transistors in earlier preamplifier systems. Other JFETs like the MPF102 will work just as well.

The 2N5139 PNP transistor provides a gain of 20 dB or so in this circuit and the transistor should be selected for a high beta, greater than 100 if possible. The Q of this circuit is about 2 which supplies some desirable reduction of low frequency and high frequency interference in the very first stages of the receiver.

Front End

The heart of the radio frequency analog circuitry involves a multistage bandpass filter with two active filters and two passive mechanical filters, as in figure 2. The signal from the preamplifier drives the first Seiko SM-31R mechanical filter directly from the 680 ohm isolating resistor which supplies power to the preamplifier. This first stage of mechanical passive filtering is followed by an active tunable bandpass filter to help reduce sideband responses and increase the system gain. A 1 k ohm pot at the output of this first active filter is used as a radio frequency gain control. The next stage is quite similar.

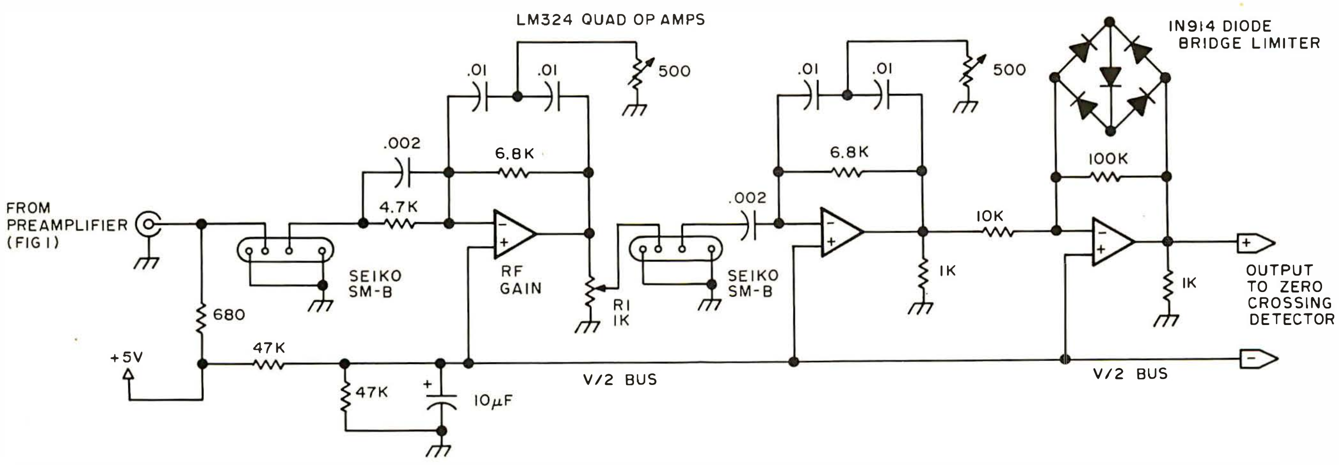


Figure 2: Mini-O mechanical filter front end amplifiers. This active circuit uses two mechanical filters manufactured by Seiko to provide a narrow bandwidth of 14 Hz at the −3 dB points and a gain of 40 to 60 dB. The output passes through a diode bridge limiter implemented with an operational amplifier section, prior to reaching the zero crossing detector of figure 3. The physical construction of this circuit is shown in photo 3.

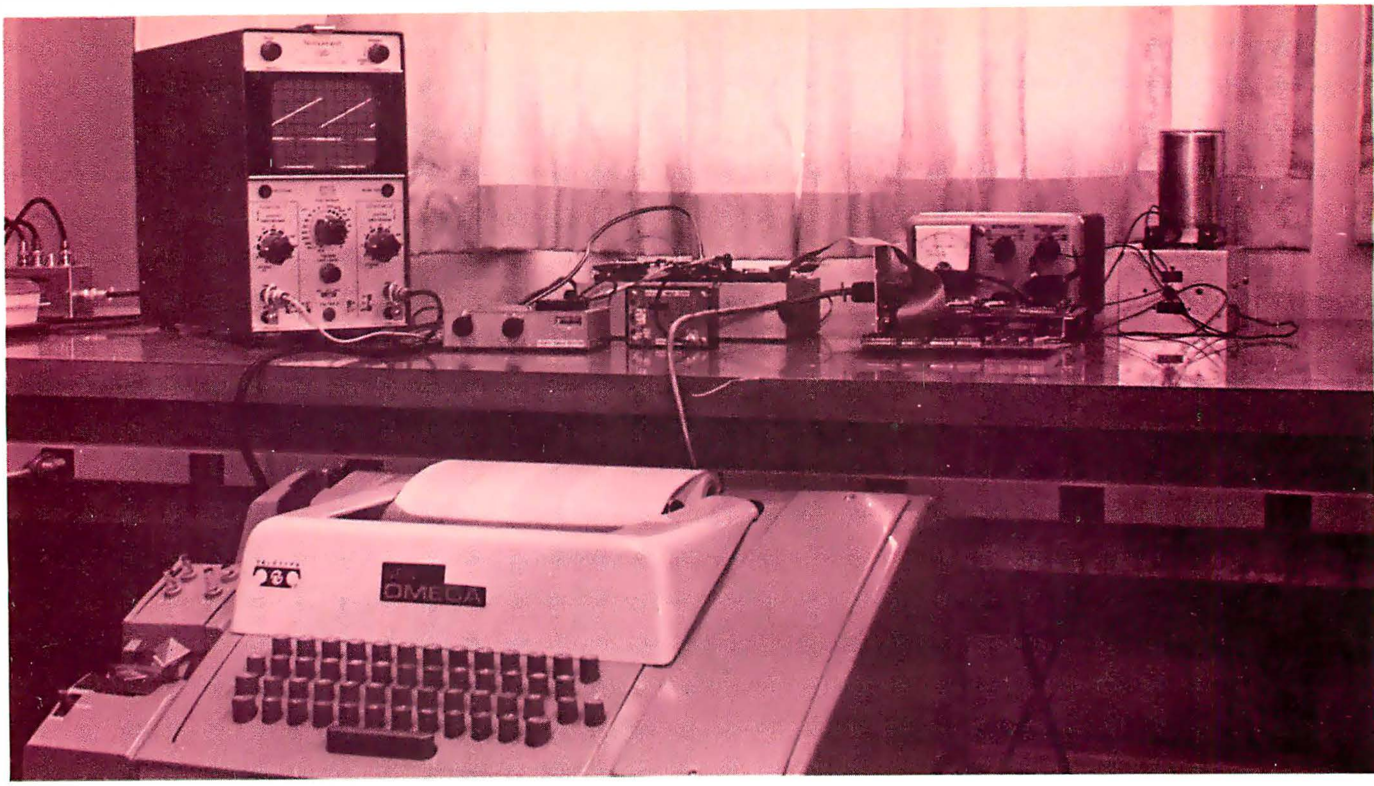


Photo 2: Mini-O in operation on the bench. The setup shown here uses a Teletype Model 33 ASR with the JOLT computer (at right in front of power supply), and the Sinclair clock reference (in front of interface box on bench). The display on the oscilloscope shows output from a lines of position digital to analog conversion output described (in concept) in part 1 of this article.

We have found that it is usually necessary to provide the 1 k load resistors to ground at the output of each of the operational amplifier stages as shown, to help reduce regeneration problems [ie: oscillations neither planned or desired] which depend on the particular parts layout on the circuit board.

The overall system gain and frequency response can be altered by changing the 6.8 k ohm feedback resistors across the first two op amps to 15 k ohms or so. However, too much gain here results in instability. The overall gain of this filter and limiter circuit is about 40 dB as shown. The bandwidth is about 14 Hz at the −3 dB points and the skirt selectivity is excellent, about −80 dB down at the next Omega channel frequency of 11.33 kHz!

Several other types of front end bandpass filter arrangements have been used with Vernitron ceramic filters and with Statek quartz tuning fork filters. However, these are more difficult to fabricate and adjust properly or involve more expensive circuitry compared to that required for the Seiko SM-31R mechanical filters.

Alignment of the filter of figure 2 is quite simple. A stable function generator with a sine wave output at 10.200 kHz is fed to the input terminal through an isolating capacitor and attenuator. The output from the limiter stage is observed on an oscilloscope and tuned for a peak amplitude by adjusting both 500 ohm trimmer resistors on the bandpass stages. It might be desirable to check the impedance matching by altering the 0.002 μF input capacitors from each SM-31R filter. These serve to "tune" the filter peak to about 10.200 kHz but are rather broad. A capacitance between 0.002 and 0.003 mF is usually required and a fixed ceramic type capacitor is adequate or perhaps two parallel ceramic capacitors to adjust each filter peak to 10.200 kHz (such as 0.002 in parallel with 0.0005). In tuning the filter circuit be sure to attenuate the signal generator to a low level so that the limiter is not clipping the peaks at the output. The operation of the limiter can be checked by increasing the drive to the filter to the point where the output starts to look like a square wave with rounded-off corners. The limiter peak-to-peak threshold is about 1 V using 1N914 diodes. Other types of limiter circuits using the MC1357 or LM2111 IC chips have also been used but the simple diode bridge circuit of figure 2 is adequate for most Omega users. If you happen to have a dual channel oscilloscope, the phase shift versus signal amplitude may

The Seiko filters are available from:

Seiko Instruments Inc
2990 W Lomita Blvd
Torrance CA 90505
Phone (213) 530-3400

Seiko also has filters for the 11.333 and 13.600 kHz Omega channels; write for information. The original SM-B filter has now been changed to type SM-31R.

Order a SM-31R 10.200 kHz 2 piece kit: unit cost $8.50 X 2 pcs = $17, postage and handling charge = $1.50 [6% sales tax for California Residents only].

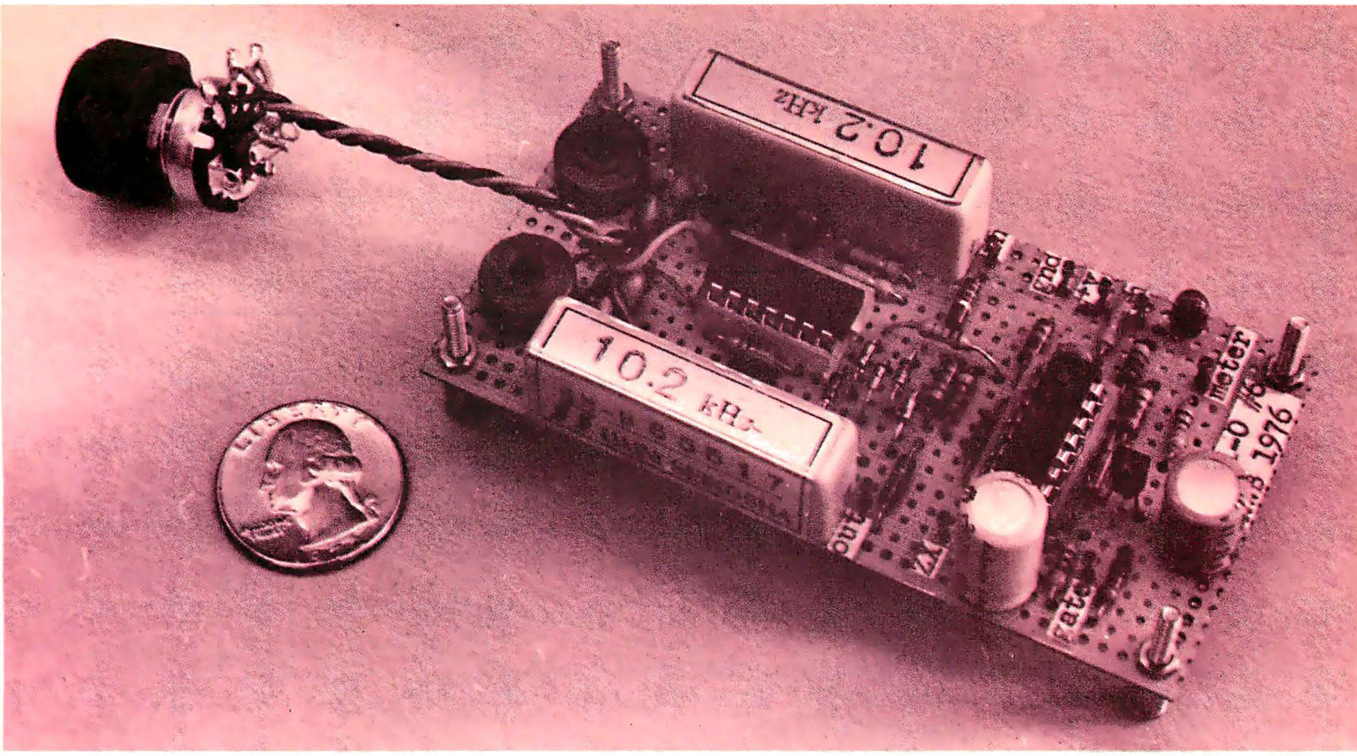


Photo 3: Mechanical filter front end board. This picture details the construction of the mechanical filter front end for the Mini-O receiver, described by the circuit diagram of figure 2. The potentiometer hanging loose at the left is the 1 k RF gain potentiometer, R1 in figure 2. The board shown here also includes the zero crossing detector of figure 3, at the right.

be checked by observing the input signal on one channel and using this to synchronize the scope sweep while observing the filter output on the other channel. There should be very little shift of the phase as the signal level is increased up to the point of limiting. At the limiter threshold only a slight phase shift should be observed. If a large change in the phase when limiting is observed, it usually means the circuit layout is poor and some kind of regeneration is taking place, or undesirable feedback; extra bypassing of the V/2 power bus with a tantalum low inductance capacitor of 10 μF might help, or reduce the overall circuit gain by changing the active filter feedback resistors to a lower value.

Zero Crossing Comparator and Envelope Gate Generator

The output of the limiter of figure 2 drives the comparator circuit of figure 3. The 10.2 kHz zero crossings are obtained from one section of a quad LM339 comparator integrated circuit. This circuit is designed with a small amount of hysteresis and is intended to be centered on the V/2 output level of the limiter stage output DC level. LM339s are not perfect and usually have a slight offset so that it is desirable to trim the exact operating point by summing a very small correction from a resistor returned to the positive power supply of +5 V. A value of 500 k ohms to 2 megohms is usually sufficient with 750 k shown in the

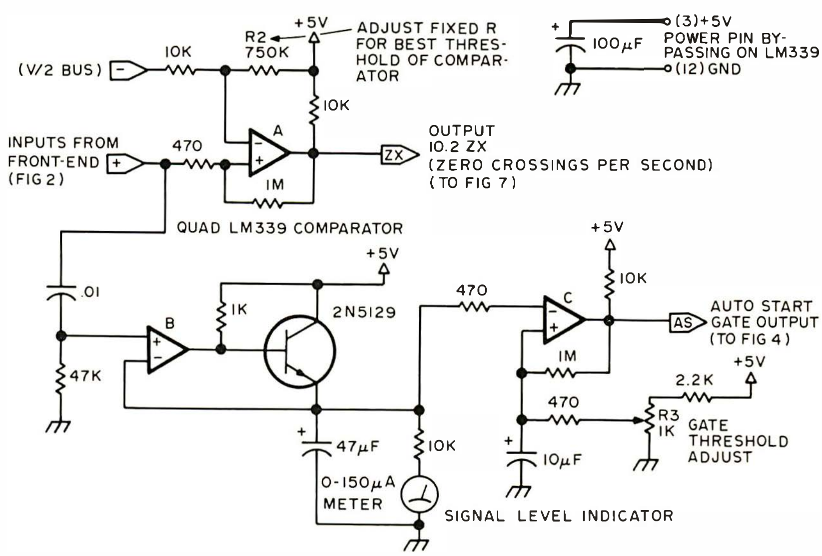


Figure 3: Zero crossing detector. This circuit shows the LM339 comparator sections used to determine zero crossing transitions (A), monitor the current signal level (B) and generate the automatic starting gate output (C) based on current signal level. The zero crossings output threshold is set by resistor R2, which must be selected to give the best threshold response. The auto start output is an "envelope gate": It is high when the signal is above the threshold set by R3, and low when below that threshold.

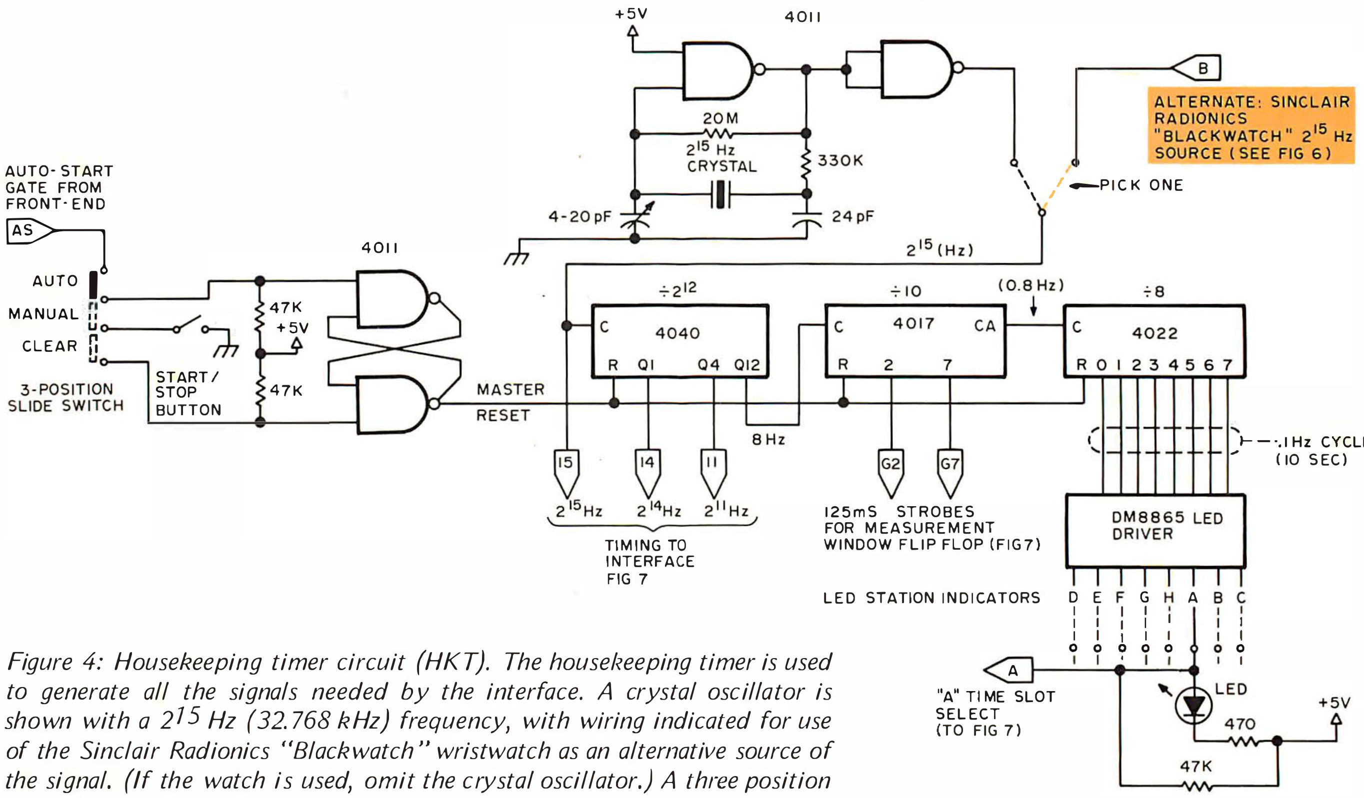


Figure 4: Housekeeping timer circuit (HKT). The housekeeping timer is used to generate all the signals needed by the interface. A crystal oscillator is shown with a 2^{15} Hz (32.768 kHz) frequency, with wiring indicated for use of the Sinclair Radionics "Blackwatch" wristwatch as an alternative source of the signal. (If the watch is used, omit the crystal oscillator.) A three position slide switch is used to control operation modes, which include automatic start, manual starting or a clear operation. The LED display driver outputs of the DM8865 provide a continuous monitor of the Omega cycle, and the A slot is monitored by the interface to the computer to give software a timing reference to stations.

diagram of figure 3. The idea here is to adjust the comparator such that it will provide a square wave output with as low as 10 mV peak-to-peak input centered on about V/2. This threshold will correspond to about 10 μV peak-to-peak at the antenna terminal (about 3 μV rms) which is usually well below the antenna noise level when the gain ahead of the comparator is about 60 dB. The front end gain will be about 20 dB for the preamplifier plus a minimum of 40 dB for the filter and limiter which provides 60 dB total. More gain can be provided if required by changing the amplifier feedback resistors on the active filters as mentioned previously. Thus the zero crossing comparator should provide an output square wave for essentially all signals and noise when the antenna is connected to the preamplifier. The output of the comparator is a hard limited square wave, but the filter-limiter circuit has what is known in the trade as a clipped linear characteristic. The edge position of the comparator square wave contains the basic phase information of the Omega signal plus the noise developed at the antenna within the filter bandwidth used.

The other sections of the comparator are used to provide an envelope output signal with a peak detector and an adjustable threshold gating circuit. The peak detector drives a signal level indicator which is handy for observing strong signals like the North American D channel on 10.2 kHz, as well as the overall receiver noise level. The meter should kick upscale slightly when the antenna is connected even in a very electrically quiet environment. The typical noise level in the 10 kHz region will vary from 10 μV to 100 μV per meter of antenna length (assuming a perfect energy transfer at the antenna) for a receiver bandwidth of 15 Hz or so. The Omega signals will vary from a low of about 10 μV to a high of 1000 μV depending on the range of the observer to the Omega transmitter. The noise level during local thundershowers can be much greater than the signal, and 60 Hz harmonic interference can often completely obliterate Omega signals as observed on a scope attached to the radio frequency front end. However, the digital processors which follow the zero crossing edge output can track signals buried in a large amount of noise with proper programming. *[Software is the touchstone of computer applications.]*

The adjustable threshold gate is used as an automatic start signal for operating the housekeeping timer (HKT) circuitry. We usually also connect an LED from +5 V through a 330 ohm series resistor directly to this gate output point to indicate when the strong D channel is on. An audio beeper

circuit connected at this point is also a handy device when first starting to observe Omega signals. This amplitude gate output is zero when on, so it operates as a current sink when driving external digital interface hardware. We have found that this circuit will start the digital logic operating 95% of the time or more, even in the presence of a lot of noise because the D channel Omega signal is quite strong for most observers in North America. For others, a manual start option is provided in the housekeeping timer circuit, and for the very sophisticated user, an automatic synchronization routine can be developed using the microprocessor with appropriate software.

Housekeeping Timer and Local Clock Oscillator

In order to operate an Omega receiver it is necessary to have some sort of timer circuitry and reference clock oscillator. The timer provides a means of telling the receiver which stations are being received, and the clock provides a reference for comparing the phase differences among stations. The clock oscillator drives the timer circuitry through an appropriate series of divider stages. A very simple housekeeping timer circuit based on a clock frequency of 2^{15} Hz is shown in figure 4.

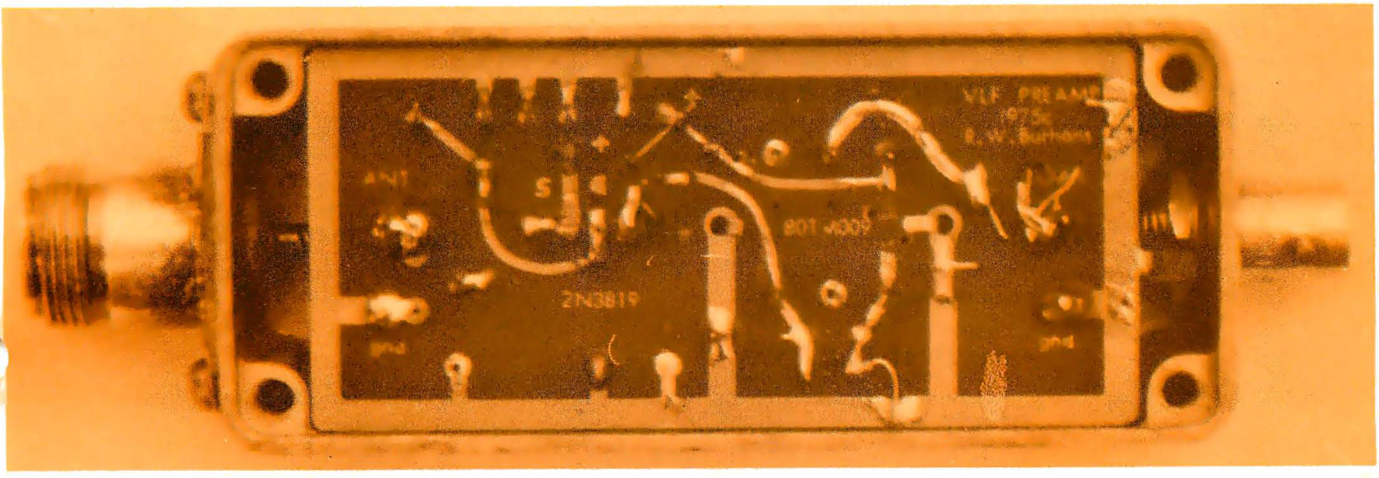
A 32.768 kHz quartz crystal of the type found in digital wristwatches is used. The timer circuitry here provides a number of very convenient gating and control signals for operating external microprocessors or hardware digital sensor systems. The timer is started with a master reset gate (MR) obtained from the front end automatic start output or from a manual pushbutton. A set-reset flip flop holds the timer on as long as the receiver is operating. The timer can be reset by switching to the stop position (or clear) and momentarily operating the same control pushbutton. The housekeeping timer tells the receiver user where the Omega sequence is with LED indicators. For a microprocessor interface only one of the stations need be selected to identify where the Omega sequence is, such as starting at the A or D channels. Beginnners might find that a string of eight LEDs, one for each time slot, is a value in understanding the operation of the Omega sequence.

A uniform measurement window method has been used in this housekeeping timer circuit. If the clock is started at the beginning of the D Omega time slot, then the sequence of gates is as shown in figure 5. A measurement window for each Omega time slot is obtained with additional clear, stop, and read gates for each one. The measurement window width can be altered by starting on pulse 1 and stopping on 8 instead of 2 and 7 as shown in figure 4. The goal here is to provide an easy way of telling the microprocessor when the measurement is valid. The HKT generates eight time slots every 10 seconds with 10 shorter 125 ms control gates for each one under the option of whatever the user desires to program.

Clock Adjustments

The 32.768 kHz clock should be adjusted for an offset of 5×10^{-6} or less. A reasonably good frequency counter with a built-in 1 MHz temperature compensated crystal oscillator time base can be used. First adjust the trimming capacitor on the clock oscillator to read 32.768 with a 1 second counter gate time. Then adjust for 32.7680 with a 10 second gate time. If a period averaging feature is available on the frequency counter, 10^4 periods of the 32.768 frequency will result in a number like 30.51757 microseconds which gives a reading of ±3 parts in 10^7 precision with respect to the frequency counter time base crystal. If you

Photo 4: The RF preamplifier, shown built with a homebrew printed circuit board and mounted in a shielded metal housing. The antenna is mounted at the left, with the connection to the receiver front end box via coaxial cable at the right.



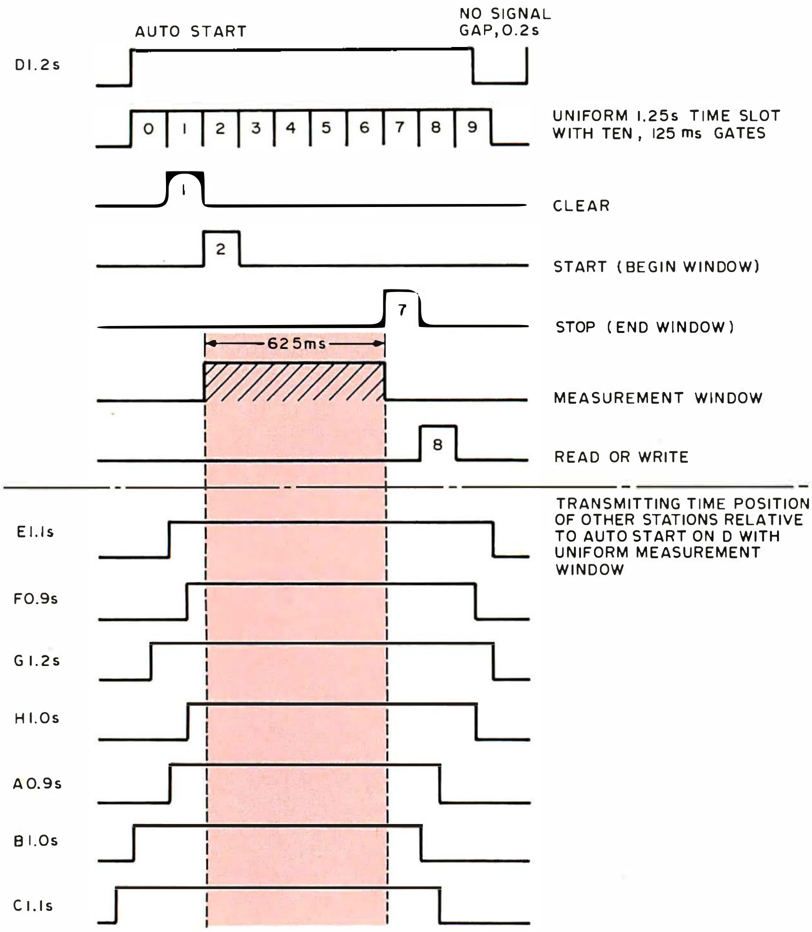


Figure 5: Timing diagram, showing how the logic of figures 4 and 7 combine to produce a hardware defined measurement window which will validly sample a segment of the signal from each station. The diagram assumes that the automatic start begins on the leading edge of the signal from the D station. The portion of the transmission interval between dotted lines in the E, F, G, H, A, B and C station signals is monitored by the Mini-O software through the interface.

do not have a frequency counter, the nearest CB repair shop usually does, and the clock may be carried to the frequency counter location for initial adjustment. Once adjusted the clock may be operated in the on-off mode with occasional checks using the Omega signal to estimate the offset for periodic recalibration.

Commercial and military Omega receivers often use a temperature compensated crystal oscillator clock on a frequency like 2.611200 MHz ($2^8 \times 10.200$ kHz). Suitable divider chains can be easily assembled to generate all of the Omega time slot functions from this particular frequency. It is also possible to devise frequency synthesizer circuits based on 5 MHz standards and some receivers have an atomic clock reference for use in the direct ranging mode. The 2^{15} Hz watch crystal oscillator provides adequate stability when treated with some care and is many orders of magnitude less expensive than other methods.

Other 2^{15} Hz Clocks

A Sinclair Blackwatch or the Westclock GT-500 wall clock movement have been used to provide the 2^{15} Hz signal with an isolating high impedance buffer amplifier. A circuit to modify the Sinclair watch kit is shown in figure 6. The output of this circuit is used to drive the oscillator of figure 4 by removing the crystal from the circuit of figure 4 and driving between ground and the input side of the oscillator gate right across the frequency trim capacitor. The GT-500 clock requires an additional 4024 divider stage to generate 2^{15} Hz from the crystal frequency of 2^{21} Hz.

Marine navigator types might find that a clock such as the Sinclair Blackwatch which has a digital display for time of day in hours-minutes, or minutes-seconds, is of value also as a celestial navigation chronometer. Once the clock has been properly adjusted, the user can even estimate when the D channel should be operating by keeping track of the clock offset on a daily basis using the seconds readout. The Sinclair watch kit can provide better than 1 second per week offset with respect to Omega. Thus the receiver user can also start the receiver manually by operating the pushbutton when the estimated D channel second interval is displayed on the clock readout. The gating system of figure 5 with uniform time slots is designed such that errors up to a quarter of a second can be tolerated and still provide some measurement window. The automatic starting gate will start using the strong D channel within 50 ms of the correct station spacing illustrated in figure 5, and manual push to start operation can be achieved within 100 ms with some practice in "clock watching."

Microprocessor Interface

The next step in the receiver operation involves converting the 10.2 kHz Omega zero crossings to a sampled set of 6 bit numbers. First a single chip rate multiplier, an RCA CD4089BE, multiplies the 32.768 kHz frequency by 5/16 to generate 10240 zps (zero crossings per second) clock rate. There will be some jitter at the LSB rate but this will wash out in the processor which needs only six of the eight bits for Omega use.

The Omega zero crossings are fed to a digital mixer circuit consisting of one D flip flop (½4013) and mixed with 2^{11} Hz obtained from the housekeeping timer circuit of figure 4. The mixing formula here is:

$$IF = f - (m+1)\, 2^n$$

where:

IF is the intermediate frequency in Hz,
f is the input frequency,
m is the harmonic number of 2^n Hz

which is nearest and lower than the input frequency,

n is an integer.

The result for Omega is IF = 40 Hz when 2^n = 2048 Hz and m = 4. We have now converted the Omega 10.2 kHz signal to a 40 Hz signal using simple digital mixing where the phase of the edges of the 40 Hz track the Omega phase within 2048/40 or within 51.2 parts per cycle. This is a convenient number in that 5 X 51.2 = 2^8. A 6 bit number (1 part in 64) can specify the Omega phase but the precision of measurement will only be 1 part in 51.2 of the actual Omega phase. This is more than adequate for simple Omega receivers which typically have errors of ±1 nautical mile, and 8 miles represents an Omega lane. In effect the binary system generates phase to within 2/100ths of an Omega cycle or lane as applied to distance measurement over the earth surface. It is also worth noting here that the phase direction of the 40 Hz signal changes opposite to that of the Omega signal, that is, the effective LO is on the high side of the Omega signal or 10240 Hz is above 10200 Hz by 40 Hz. This is of no consequence since the subtraction to obtain the correct line of position direction can be reversed using complementary arithmetic.

The 40 Hz output signal from the mixer is inherently noisy and also contains higher harmonics of the LO. A binary phase lock loop (BPLL) consisting of the 4030-4011 and 4040 CMOS chips of figure 7, provides nine bits of filtering and a clean 40 Hz signal. The phase data contained in the 40 Hz edges may actually be used at this point without any microprocessor by starting an RS flip flop with an 8 Hz edge obtained from the housekeeping timer and stopping with the next 40 Hz edge. The width of the resulting on-off pulse is directly proportional to the phase of the original 10.2 kHz Omega signal with respect to the local clock which generates the 8 Hz reference. A suitable counter, averaging, and subtraction circuit can be devised in hardware to measure Omega lines of position where the filtering time constant will be the width of the gating interval of figure 5, or about 8 Hz/5 for a bandwidth of 2 Hz.

For microprocessor use we sample the cycling 40 Hz clock obtained from the rate multiplier and 8 stage counter of figure 7, with the 40 Hz Omega signal from the binary phase lock loop filter. An 8 bit three state latch (4508) stores the individual Omega phase readings as 6 bit data and the other two bits of the latch are used to store the station status information from the gating circuitry of figure 7. These 8 bit

Integrated Circuits for VLF-LF Receivers

In our VLF-LF navigation lab at Ohio University we have found a great many standard IC chips useful for Omega (10 kHz range) or Loran-C (100 kHz range) receivers. Experimenters skilled in the art of fabricating high gain receiver circuitry might wish to substitute various other circuits for the Mini-O front end system. The following list of ICs has been used with both Omega and Loran-C systems:

AM Receiver Chips (identical circuits)

Fairchild	uA720
National	LM1820
RCA	CA3123
Signetics	N546

AM-FM-SSB Receiver Chips (not identical circuits)

Fairchild	uA721
National	LM373 or LM374
Plessey	SL1624C
RCA	CA3089

FM Limiter-Detector Chips (used as envelope detectors by feeding input to limiter, also to quadrature input)

Fairchild	uA721	
Signetics	ULN2111	identical types
National	LM2111	identical types
RCA	CA2111	identical types

FM Limiter Amplifiers (not identical circuits)

Signetics	ULN2208
Signetics	ULN2209
National	LM703
National	LM371
National	LM370 (AGC type)
Fairchild	uA757 (AGC type)
RCA	CA3028
RCA	CA3053

There are probably others which would be suitable; refer to the manufacturer's literature and application notes. One of the newest types, the Fairchild uA721, appears to work for both Loran-C and Omega receivers and has the potential for providing a noise blanker using the mixer stage, without adding any additional active circuitry to the front end.

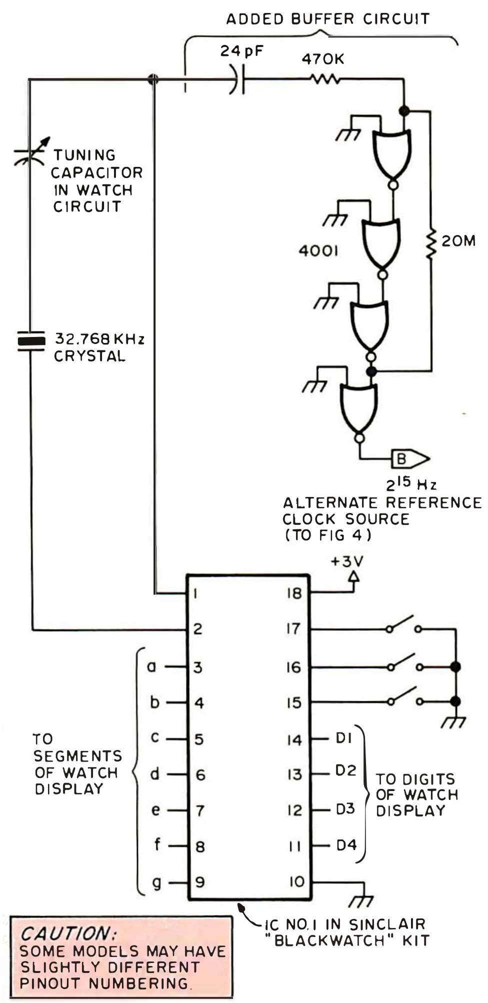


Figure 6: Use of the Sinclair "Blackwatch" wristwatch kit as a source of the 2^{15} Hz reference signal (32.768 kHz). This circuit was used by the author to provide both chronometer functions and Omega reference timing by mounting it in a plastic case so that the LEDs could be seen (see photo 2).

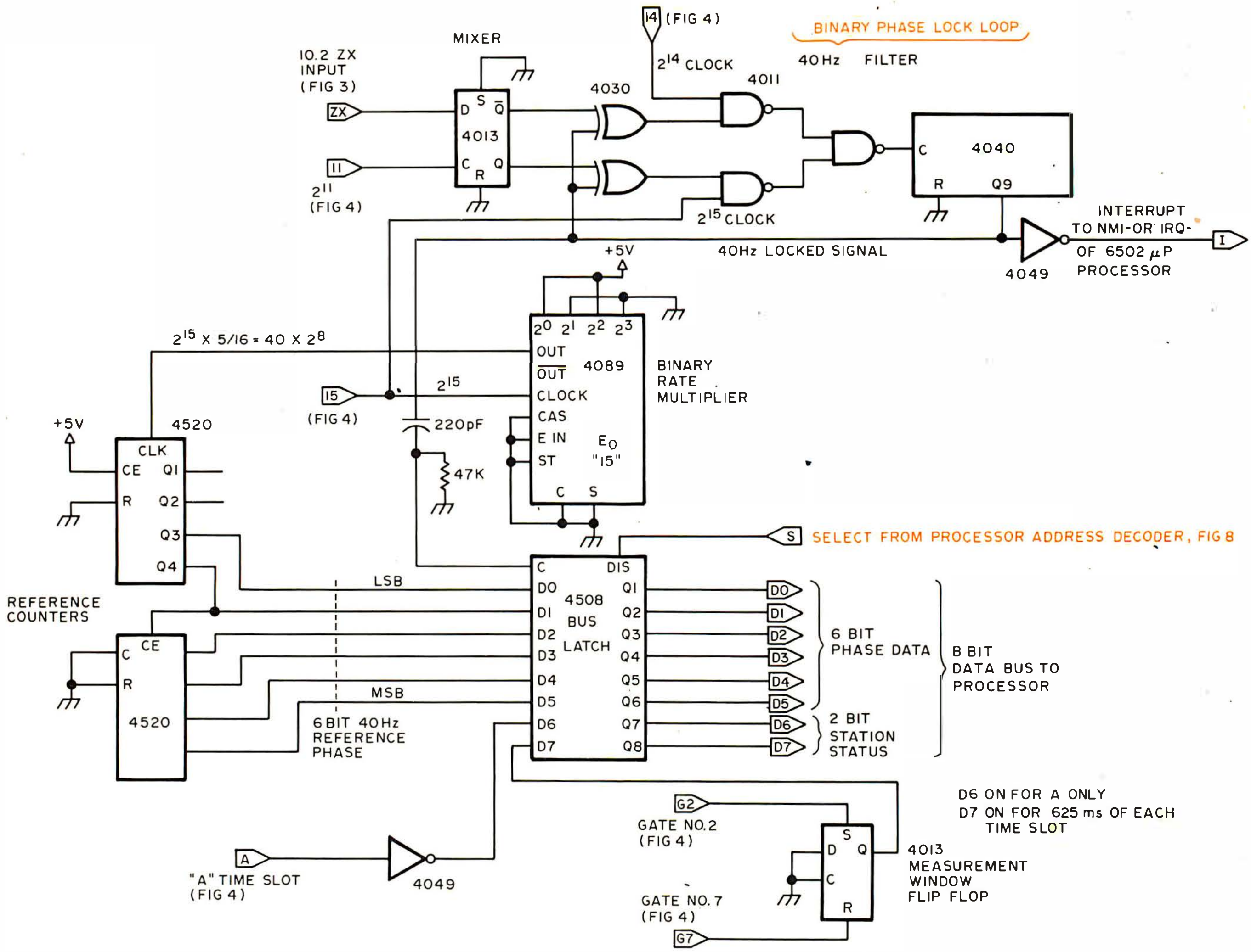


Figure 7: 8 bit processor interface. This is the interface used with the JOLT or KIM-1 versions of an MOS Technology 6502 in the author's laboratory. The address selection logic is shown in figure 8. The mixer and phase lock loop generate a 40 Hz difference frequency which drives the processor's interrupt line. This signal also provides the latching signal to the 4508 bus interface, so that when the processor responds to the interrupt it will have the data which was current at the time of the interrupt. The binary rate multiplier (4089) is used to divide the reference frequency to provide a crystal controlled clock into the reference counters, so that the count of crystal controlled cycles can be read following the interrupt.

numbers now become the raw Omega data for processing and status using interrupt requests to the microprocessor at every 40 Hz positive going edge. The data is used as if it were high order memory address with a decoder from the microprocessor address lines and output to the 8 bit data bus with appropriate software, figure 8. There are other ways of implementing the interface with about the same hardware depending on the particular microprocessor system used.

If the 625 ms sample window of figure 5 is used, then there are 25 Omega phase readings valid for each time slot. That is, there will be 25 cycles of the 40 Hz signal in 625 ms. The microprocessor software designer can manipulate this data in various ways. Some receivers first estimate a mean or mode value. Many Omega processing systems create a software tracking loop which is similar in principle to a phase locked tracking loop as used in analog circuits. This can be done in the 40 Hz case by programming in increment-decrement addition to the 40 Hz interrupt edge position such that the new calculated position will tend to be exactly at the same phase value for each reading. This estimate is stored in memory for each time slot creating what we would call a software memory aided phase locked tracking loop. The loop output becomes the phase of each time slot with respect to the cycling 40 Hz reference clock and is subtracted in pairs to generate lines of position.

A microprocessor can be programmed to do this with 100 or so instructions. An equivalent hardware memory aided phase locked loop and lines of position subtraction would require at least 20 additional integrated circuits as well as a memory. Thus the

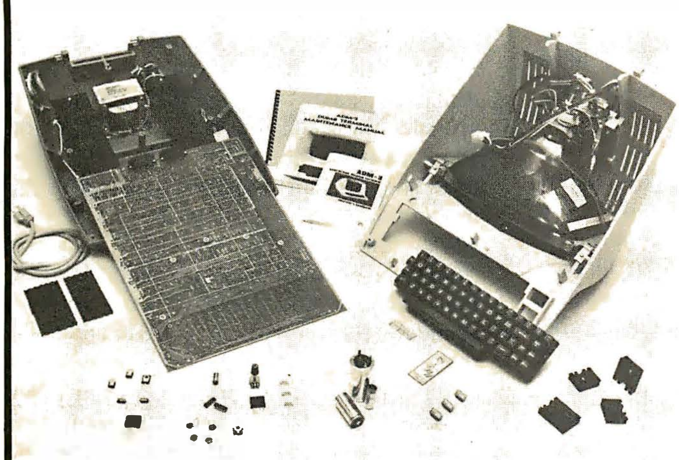
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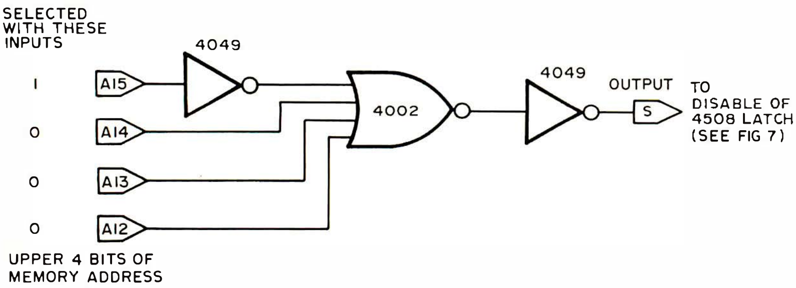


Figure 8: Partial address decoder. In a small system, where only a portion of the total address space is actually used, it is possible to get away with partial decoding of addresses. This decoder lumps all addresses of the form hexadecimal 8xxx together as the (single) address for the Omega interface; for systems where memory address space utilization is a problem, other address decoding configurations should be used.

Acknowledgments

At Ohio University we have been developing low cost Omega navigation systems (ONS) for use by the general aviation community. The Mini-O system described here is a spinoff of some of the simpler ideas. Part of the work reported here has been supported by NASA Langley Research Center, Grant NGR 36-009-017, under the Tri-University Program in Air Transportation. The aid and support of Dr R H McFarland, Dr R W Lilley, Prof G E Smith, R J Salter, Lee Wright, Kent Chamberlin, Dan Moyer, and Ralph Smith are much appreciated on the project results.

microprocessor can do this job as well as all the remaining computation to output some useful navigation information and still have space left for whatever the system designer wishes to do.

At this point we leave it up to the software designer to implement a navigation system on the microprocessor. We have supplied raw phase data at a suitable low data rate (40 Hz), a collection of Omega sequence and time signals for interrupt and control of microprocessor functions, and means of identification of where the Omega sequence is at a particular time. The first stage in programming involves developing sensor processor filtering of the data down to the lines of position level. The simplest marine receiver might require only two lines of position outputs. Further sophistication would involve conversion to latitude and longitude, range angle, diurnal corrections, multiple frequency redundant systems, differential corrections, etc. The next article in this series, by Richard Salter of our laboratory, presents some of the sensor software details.

Test Equipment Recommended

The Mini-O receiver system is intended for fabrication by those skilled in modern electronic circuit arts. It is not recommended for the total novice. Access to some test equipment is required for alignment and checkout. An oscilloscope, preferably a triggered sweep model, a stable audio function generator, and a frequency counter with a quartz crystal time base, are suggested.

The function generator should be capable of tuning the range of 5 kHz to 20 kHz with some reasonable stability (with an internal regulated DC supply) and a tuning rate such that the frequency of 10.200 kHz may be set to within a few Hertz. The adjustment of the very narrowband front end requires setting the function generator to the center frequency of 10.200 kHz and this should be checked with the aid of a frequency counter operating in parallel or triggered from the function generator synchronizing output. We have used the EXAR model XR-2206KA kit (available from James Electronics, POB 822, Belmont CA 94002, for about $18 as a basic chip plus circuit board). This provides a convenient squarewave output for checking frequency in parallel with the sine wave output. A good quality logarithmic tuning potentiometer is required in these types of function generators.

The frequency counter should have a 10 second time base with a quartz crystal reference that is accurate to within $\pm 1 \times 10^{-6}$, or has a low offset. If you do not have this item, many radio amateurs often use them in their shacks, as well as CB repair shops. Some frequency counters have provision for using an external time base which can provide the required precision for initial adjustment of the 32.768 kHz clock oscillator. The Sinclair Blackwatch kit also has instructions for adjusting the offset using WWV time ticks on the high frequency (short wave) radio bands. This takes longer than using a good frequency counter but is adequate for the patient experimenter. For the experimenter who is involved with time and frequency measurements, a good 1 MHz secondary standard is suggested. Many oven controlled crystal oscillators are on the surplus market. (Herbach and Rademan, 401 E Erie Av, Philadelphia PA 19134, has several with proportional oven controls in the $30 to $50 price range; a reasonably priced temperature compensated crystal oscillator is available from Bliley Electric Co, 2545 W Grandview Blvd, Erie PA 16508, the model TCCO which requires 26 mA +5 VDC and costs about $75.)

Some experimenters might even wish to consider the possibility of using an external 1 MHz frequency standard as the microprocessor clock system so that all of the timing functions could be accomplished with precision using the microcomputer itself without ever using a special purpose Omega clock in the interface.

When using an oscilloscope, it is suggested that most measurements be made with a low capacitance probe so that the waveform displayed will not be distorted by the lead capacitance to the scope. When observing the input signal at the preamplifier output terminal or at the input to the front end, an ordinary coaxial lead to the scope may be used because the impedance at this point is about 680 ohms. However, the output of many of the CMOS logic circuits is a much higher impedance, and distortion of the actual waveform will take place unless a low capacitance probe is used. The CMOS logic circuits will tolerate up to something like 130 pF additional capacitance, but this can distort a 1 MHz signal.■



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Continued from page 13

attempting to sell the user the idea that the DEC PDP-8 that drove the reader would fit in the palm of his hand in a few years. The Intel 8008 was just out, and those outside the integrated circuit world could not understand its potential.

In printers' terms the paper has a line screen of 25% density, similar to a printed photograph. All we did was to place the dots where we wanted them. To do this the RCA Vidiocomp was driven with our dot "font." The worst problem in producing the master was that the technicians adjusting the Vidiocomp did not really do a good job on the sweep linearity. It wasn't necessary in text, but it really came out in our reader. The data is encoded in a phase-like method where along the scan line the black dot is placed to either the right or left side of the cell, thus a black white or a white black. When scanned and converted to an analog signal, you have either a positive or negative transition at the cell center the same as many cassette tape recorders. This was done as we had just finished a cassette recorder design. The reader has a three cell scan head. Two cells track the line, and the third is the data cell. The organization is like a disk, where the first few lines at the beginning are a disk directory – in this case chapter paragraph line number starts. You can use the runout on each side to count your position the same as a disk head position encoder.

If anyone wants more information please contact me, C R Conkling Jr, at POB 310, Shoreham NY 11786, (516) 744-9475.

GRAY SCALE?

I am following your series of articles on the optical bar code readers with great interest. Basically I agree with Messrs Banks and Sanderson (December 1976 BYTE, page 12) that optical bar code readers and low cost printing will be "the way to fly." I would add that software would best be distributed as source code, although the technique could obviously be used for source or object code. I would suggest that the suggested format (figure 2, page 16) be enlarged to include a one byte "record type" code. This would allow for a far more flexible system at very small cost.

I borrowed my son's (inexpensive) microscope and gave the sample bar codes (figure 4, page 17) a close look. One thing became quickly apparent: Even on the low density sample a lens system of at least 200X was required! Any less and I could see more than one bar at a time. Secondly, holding the paper flat to prevent misfocusing was a problem. The high density samples had a problem obvious to the unaided eye – the ink smeared (see copy enclosed). My experiment indicated that your sample (e) was about the best. Sample (c) came close, but might present problems in tracking.

Several thoughts on the subject: Some form of audio feedback from the computer (have the processor make a "click" noise by toggling a one bit output port into a speaker) would help maintain the correct scan rate and tell when you had strayed off the track. Perhaps the bar code system is not the ultimate way to go; how about a "gray scale" – you could print white, 33% halftone, 66% halftone, and black (giving four levels) or what have you. The halftone system would allow printing of wider bars while yielding high bit density, thus reducing the requirements of the lens system. One final thought: With proper forethought, the bar code "pencil" could double as a "light pen."

Please keep up the good work, especially on this subject. I believe you are on to something very worthwhile.

Carl K Zettner W5HFG
108 Moss Dr
San Antonio TX 78213

As noted earlier (see January BYTE, page 11) the smearing of the high density samples and variability of the spacing rule out their use. The actual problem can be attributed to a nonuniformity in the response of the photographic preparation of the plates for the print run, since the smearing was seen in our "blueprint" proof copy of December BYTE.

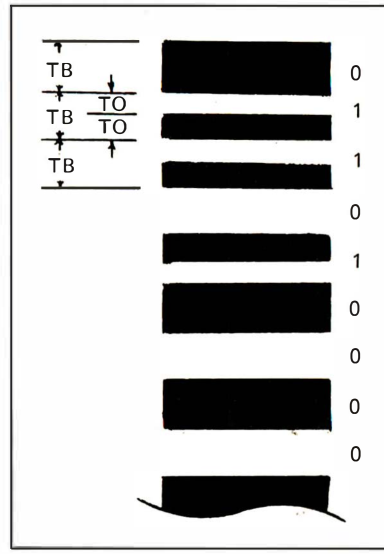
The magnification of the optics is not the problem; rather it is the aperture of the lens, and masking of that aperture so that only one bar width at a time is viewed. The slit method (see comments in another section of this forum) shows good promise as an inexpensive but quite usable form of optics for bars such as those we've printed in recent tests. The larger the area of the opening, the greater the amount of the bar which is sensed. The narrower the effective aperture (whether or not a lens is used), the higher the density can be made.

NRZ, ANYONE?

I was very glad to see your article on bar coding, and I hope it will be a success. There are a couple of improvements I'd like to see, though.

Since you're printing the bar code, won't you *please* print the same data in human readable form, too? The Universal Product Code has the numbers printed. Punch cards have their problems, but at least with them you can tell exactly, character for character, what's going into the machine. With paper tape (or your bar code formats) you can puzzle it out, but only with a lot of work. Of course, with magnetic tape there's no hope. You're suggesting 50 bits per inch *[not anymore]* so you could print the corresponding hexadecimal characters immediately below the bars at 12.5 characters per inch. (I've found 12 to 21 characters per inch in BYTE articles.) Of course, if you're printing ASCII characters, the characters themselves could be used instead. If a misprint keeps one frame of bars from being read, I'd sure rather key in 125 hexadecimal characters than 500 painfully deciphered bits.

Since bar codes can be the same as saturated magnetic tape codes, I'm surprised you didn't suggest the NRZ (Non Return to Zero) code. In it, the medium is divided into equal cells. A transition (from white to black or black to white) in the center of a cell represents a one, while no transition represents a zero. A transition also occurs at the end of every cell for timing. Although more difficult to read manually than your formats two or three, this code has even spacing and is more compact:



If we assume, in each of these formats, that the short spaces and bars are half the width of the long spaces and bars, and that 50 bits per inch is a reasonable density for format 2, we can calculate the corresponding densities for the other formats:

Format	Density (bits per inch)
1	75-150, average 100
2	50
3	50-75, average 60
NRZ	75

[We have to figure out how to do it first . . . but maybe . . .]

I think the NRZ code with hexadecimal or ASCII characters would be a good compromise.

To encourage use of your bar code standard, BYTE could offer to convert data from tape to bar code for anybody at a standard price. That way other magazines, particularly those on small budgets like club newsletters, could use it. If it were only a few dollars a page, bar coding would be cheaper than cassettes (though slower to read) even for a "production run" of half a dozen!

Finally, a hard copy printer or even a typewriter can print a low density bar code: 010001101 can be scanned right

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down the center of the characters! *[See Fred Howard's letter.]*

Keep up the good work.

James R Van Zandt
26 Shelton St
Nashua NH 03060

Using software (although this may be premature), NRZ may very well be much more complicated to decode. But it may be worth trying. Since the format of the light and dark we print has no bearing on the hardware, provided we use bars with physical minimum size parameters set by an aperture standard, it only requires a night or weekend's worth of software and some experiments with PC layout tape, white paper, a darkroom and a camera to try out a different format at the bit level. In actual program object or source code, we plan to print an exact hexadecimal map of each bar code frame, thus allowing both hand and machine readable data entry.

SPACES CARRY NO INFORMATION?

Harold Mauch sends us this commentary, which we print with a few words at the end:

I would like to take exception to the choice of proposed format for the "Machine Readable Printed Software" described on pages 12-17, BYTE magazine for December 1976. Of the three formats described, the selected format (format 3, page 14, figure 1) has the least going for it.

- It is lower density than format 1 since the spaces carry no useful information.
- Contrary to the assertions of the author, the spaces provide only a marginal reference for discriminating wide from narrow bars.
- The hardware and/or software needed to implement format 3 is more complicated than that required to read either format 1 or 2.

Examination of the test strings on page 17 indicate the typesetting, lithographic and printing process is far from "perfect" in maintaining bar to space ratios. To compensate for this imperfection, author Keith Regli added a "bias computation and adjustment" to the space count, thus complicating the software.

Such ad hoc measures could be eliminated with format 1. The printing process maintains excellent bar to bar and space to space ratios, but poor bar to space ratios. The lithographer may have over or under exposed the plate or the printing press may be running too much or too little ink. A more satisfactory approach for discriminating between wide and narrow bars is to compute the average of known wide and narrow bars (add the counts and shift left once). This provides a discrimination threshold with which other bars in the local area may be compared. The same procedure would apply to wide and narrow spaces. Even with the addition of reference bars and spaces, the average data density of format 1 is 33% greater than format 3 and 60% greater than format 2.

While on the subject of reference bars, format 3 needs them also. If the data is a string of zeros, I claim that the printing variations evident in the test strings on page 17 will eventually confuse the decoding algorithm. This can be resolved by adding a reference or parity bar, preferably to each 8 bit byte. This required addition thus gives format 1 a 50% density advantage over format 3.

I presently use and prefer a signal conditioner circuit nearly identical to that described in author Merkowitz's article (page 81, figure 3). The super differentiator circuit of figure 4 is better for low density waveforms since the photo sensor output is nearly a square wave. However, when bar and space width is decreased to the dimension of the photo sensor's effective aperture (0.005-0.010 inch in my equipment), the photo sensor output looks more like a sine wave which does not differentiate into the narrow pulses required by the threshold comparator of figure 4.

One final note: My experience is that timing bits alluded to in figure 2, page 16, are required, not for timing, but to permit the signal conditioner detectors to stabilize. Referring to figure 3, page 81: When the photo sensor is resting on the white page before a line of code is scanned, the peak detectors will decay to the "white" level. This creates a severe white bias until the "black" peak detector stabilizes. The result is that the measured duration of the first few bars and spaces of a line will be grossly distorted and not suitable for data.

Harold A Mauch
Director of Engineering
PerCom Data Co
4021 Windsor
Garland TX 75042

The point about format 1 versus format 3 needs some comment. First, the format 3 spaces do carry useful information – they give the timing values needed to discriminate bit widths. The bias calculation is required also in format 1, which will suffer from the same problems in the switching of the levels. (This problem is caused by the tendency of the system to take different amounts of time to change state from black to white than vice versa.) By using explicit black marks for each bit, at least we are guaranteeing that each bit has the same biases (one rising edge to black, one falling edge to white). We don't care about bar to space ratios other than the fact that they are locally constant within a space of several bits retained in the running average of the input algorithm.

The startup bias also depends upon your detector design, and later conversations with several engineers suggests that the circuits of Fred Merkowitz's articles are overly complex for this application . . . CH ■

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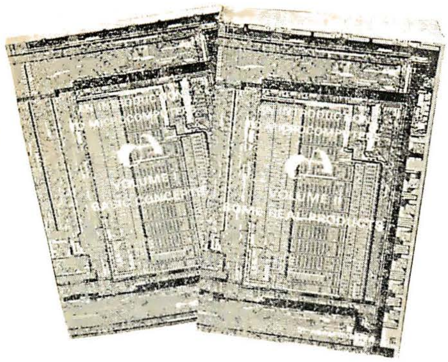
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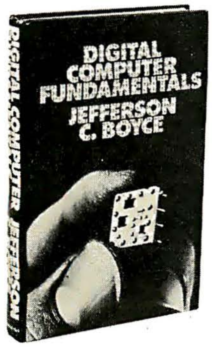
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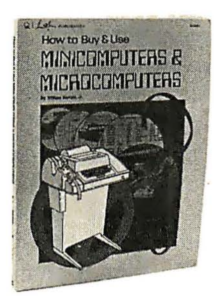
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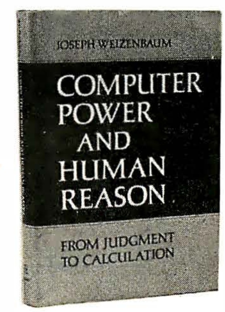
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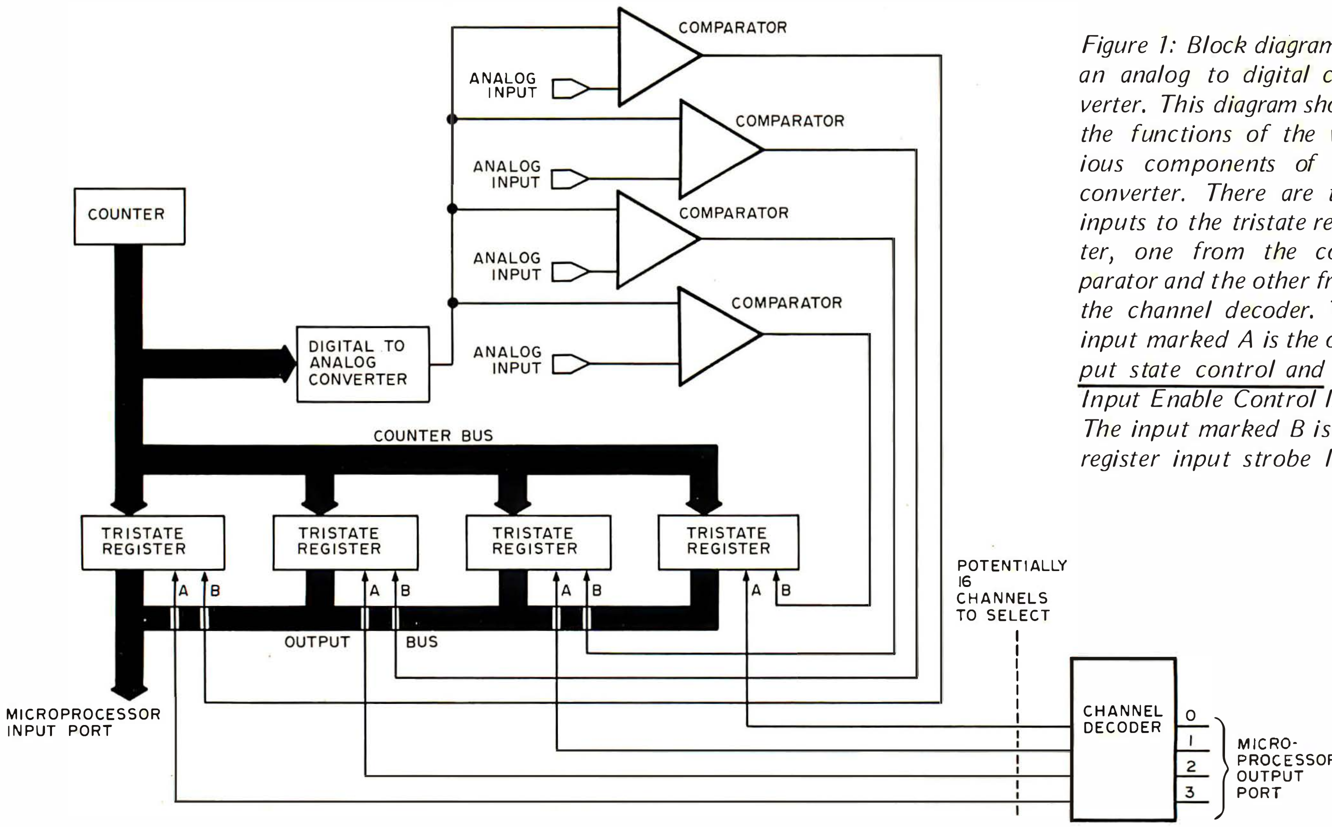


Figure 1: Block diagram of an analog to digital converter. This diagram shows the functions of the various components of the converter. There are two inputs to the tristate register, one from the comparator and the other from the channel decoder. The input marked A is the output state control and the Input Enable Control line. The input marked B is the register input strobe line.

An Inexpensive Joystick Interface

Thomas R Buschbach
12310 Purcell Rd
Manassas VA 22110

In the quest to develop the ultimate in video games, the need arose to interface analog controls to a microprocessor. A common control used in most video games is the joystick. It allows you to control two axes with one device. A joystick usually has potentiometers mounted on two adjacent sides as shown in photo 1. The potentiometers vary their resistance from 0 ohms to their maximum value as the control stick is moved. The change in resistance is proportional to the displacement along the axis parallel to the surface the potentiometer is mounted on. All that remains is to convert these resistance values into digital values which the microprocessor can manipulate. To develop a full range of two and four player games, I decided four joysticks would be required. To interface four joysticks to the microprocessor would require eight channels of analog to digital conversion. Since the commercial analog to digital converters cost approximately $50, buying eight of them was prohibitively expensive. Even buying only one and multiplexing its inputs and outputs seemed to be more expensive than necessary.

Being a typical software fanatic, I had no desire to build my own analog to digital (AD) converter. However, after examining all the alternatives, I decided to build Roger Frank's circuit (BYTE, May 1976, page 70),

Listing 1: This 8080 op code will read the digital value for the desired analog to digital channel. The digital value is left in the accumulator. All numbers in this listing and listing 2 are in octal.

octal address	octal code	op	operand	commentary
000	076 XXX	MVI	A,XXX	A:= number of desired channel;
003	323 AAA	OUT	AAA	output channel to unit AAA
005	333 BBB	IN	BBB	read digital value of channel from BBB
007	365	PUSH	PSW	save digital value;
010	227	SUB	A	clear accumulator and flags;
011	323 AAA	OUT	AAA	clear output port to 0;
013	361	POP	PSW	restore saved value;

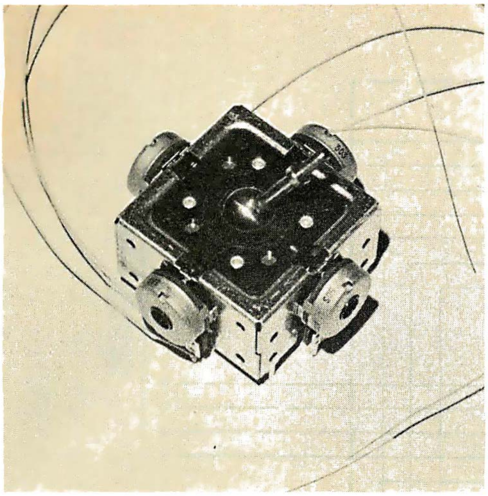


Photo 1: This is a typical joystick showing the potentiometers that are mounted on each side of the device and wired in parallel.

which utilizes a digital to analog converter (DAC) and a software algorithm to do the analog to digital conversion. After ordering the required components I decided that using a software algorithm to do the conversion for eight channels of analog to digital conversion would not leave the processor time to process the game's algorithm. At this point I decided to implement the software conversion algorithm in hardware.

In developing the circuit I had four design goals in mind:

- Interface at least four joysticks, eight channels analog to digital.
- Use no more than one input and one output port.
- Use no processor cycles for the conversion process.
- Sample each analog signal at least 1000 times per second.

A block diagram of the circuit is shown in figure 1. The detailed functions of the digital to analog converter and the comparators are explained in Roger Frank's article mentioned earlier. If you are considering constructing this circuit, I would recommend reading that article.

The circuit is controlled by a counter which continually counts down from octal 377 to 0, driving the inputs of a digital to analog converter. The output of the converter is compared to the analog input signal from the joystick. As long as the converter output voltage is higher than the

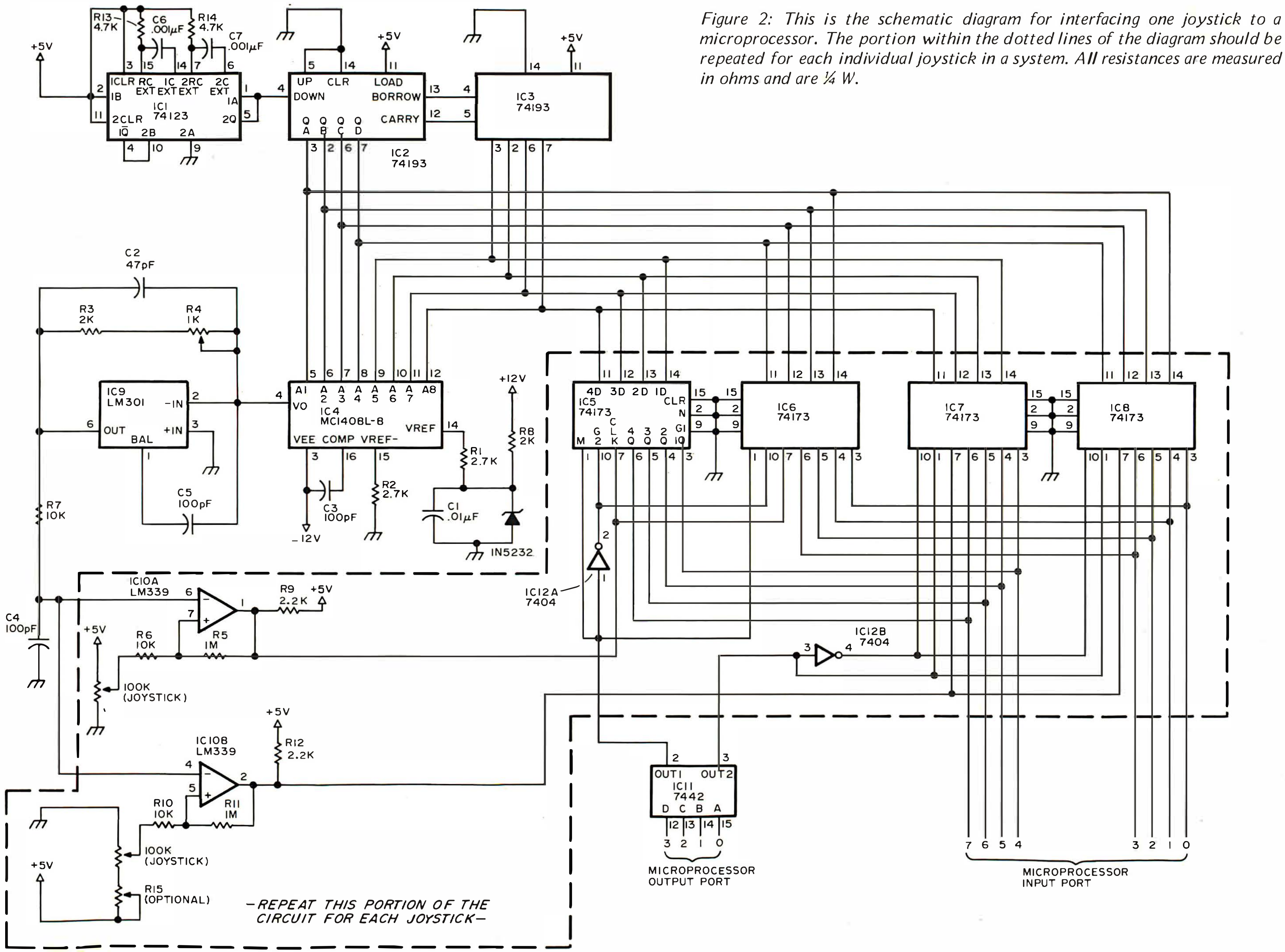


Figure 2: This is the schematic diagram for interfacing one joystick to a microprocessor. The portion within the dotted lines of the diagram should be repeated for each individual joystick in a system. All resistances are measured in ohms and are ¼ W.

voltage from the joystick, the output of the comparator is 0. When the counter has counted down to a value which causes the converter to output a voltage equal to, or slightly below, the voltage from the joystick, the comparator output goes high. This edge triggers the corresponding tristate register to load the current value of the counters. This occurs asynchronously for each channel.

To access the digital value for the desired channel, you output a number from 1 to 8, corresponding to the desired channel, on an output port. Leaving this value latched in the output port, the digital value may be read from the desired input port. Clearing the output port to 0 completes the operation. This operation is shown in listing 1.

Figure 2 is the schematic to interface one joystick to the microprocessor. The circuit may easily be expanded to handle four joysticks. The 74123, IC1, is used as a multivibrator to generate a pulse waveform. With the resistance and capacitance values shown it will have a frequency of approximately 0.3 MHz. This pulse train drives the count down input of the 74193 counters IC2 and IC3 which form an eight bit binary counter which continually counts from octal 377 (or hexadecimal FF) to 0. The outputs of counters IC2 and IC3 are tied to each tristate register pair (IC5 and IC6, and IC7 and IC8) and to the digital to analog converter, IC4. This latter circuit produces a negative ramp continually going from +5 V to 0 V in 256 steps. The output of IC4 is converted from a current to a voltage signal by IC9. One quarter of IC10 is used to compare the output of IC9 to the voltage from the joystick. The output of each quarter of IC10 is tied to a single tristate register pair. This output remains a logical 0 as long as the voltage from IC9 is greater than the voltage from the joystick. When the voltages are equal the output of the corresponding quarter of IC10 shifts to a 1. This edge triggers the corresponding pair of registers to latch the value of the counters at

Table 1: Power connection table for the circuit of figure 2.

Number	Type	+5 V	GND	−12 V	+12 V
IC1	74123	16	8		
IC2	74193	16	8		
IC3	74193	16	8		
IC4	MC1408L-8	13	2		
IC5	74173	16	8		
IC6	74173	16	8		
IC7	74173	16	8		
IC8	74173	16	8		
IC9	LM301			4	7
IC10	LM339		12		3
IC11	7442	16	8		
IC12	7404	14	7		

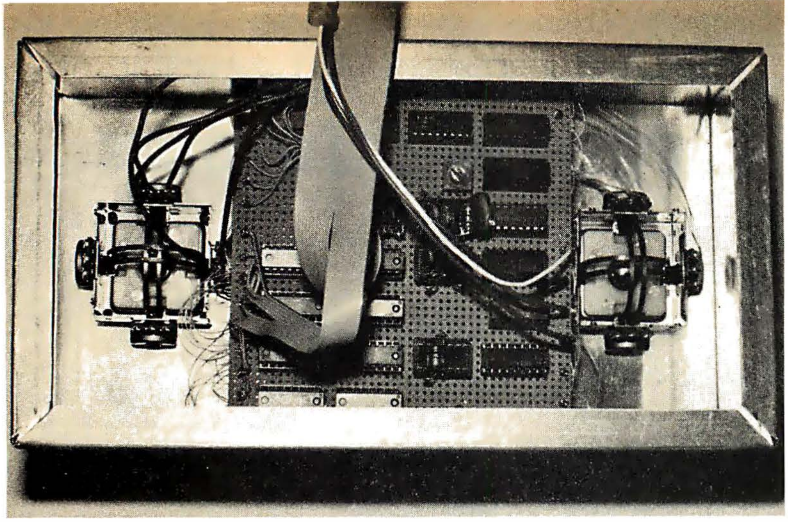


Photo 2: Underside of finished assembly showing wire wrap board and two joysticks.

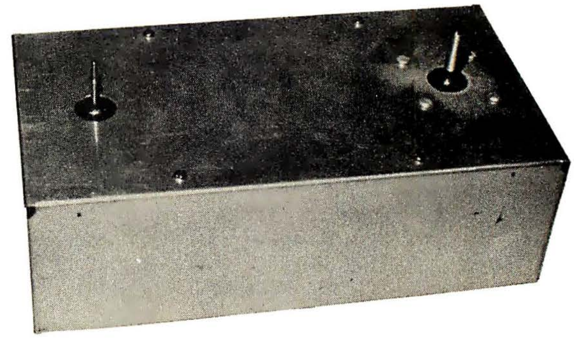


Photo 3: This is the top view of the finished unit showing the two control sticks; the connectors are for input port, output port and power. An identical box with two more joysticks will plug into the side of this box for games requiring four joysticks.

Listing 2: This subroutine will read the digital value from a requested analog to digital conversion channel, set minimum and maximum values, apply a scaling factor, add or subtract an offset value, and then return the resulting value in the accumulator to the calling program. The program can be located at any high order address, symbolized by <x> in the listing.

octal address	octal code	label	op	operands	commentary
000	176		MOV	A,M	A:= channel number;
001	323 002		OUT	2	output channel number;
003	333 002		IN	2	input digital value;
005	043		INX	H	HL:=HL+1;
006	107		MOV	B,A	B:=digital value;
007	227		SUB	A	clear output port;
010	323 002		OUT	2	
012	176		MOV	A,M	A:=minimum value;
013	270		CMP	B	if B>A then go to JP1 [not lower limit];
014	332 020 <X>		JC	JP1	
017	107		MOV	B,A	else B:=A [set lower limit];
020	043	JP1	INX	H	HL:=HL+1;
021	176		MOV	A,M	A:=maximum value;
022	270		CMP	B	if B≤A then go to JP2 [not upper limit];
023	322 027 <X>		JNC	JP2	
026	107		MOV	B,A	else B:=A [set upper limit];
027	043	JP2	INX	H	HL:=HL+1;
030	227		SUB	A	clear accumulator and flags;
031	206		ADD	M	A:=A+scale factor;
032	372 054 <X>		JM	JP3	if scale factor negative then go to JP3;
035	312 070 <X>		JZ	JP4	if scale factor zero then go to JP4;
040	127		MOV	D,A	D:=A;
041	170		MOV	A,B	A:=B;
042	027	JP5	RAL		shift left;
043	067		STC		clear carry;
044	077		CMC		
045	025		DCR	D	D:=D−1;
046	302 042 <X>		JNZ	JP5	if D≠0 go to JP5;
051	303 067 <X>		JMP	JP6	go to JP6;
054	346 177	JP3	ANI	177	mask most significant bit;
056	127		MOV	D,A	D:=A;
057	170		MOV	A,B	A:=B;
060	037	JP7	RAR		shift right;
061	067		STC		clear carry;
062	077		CMC		
063	025		DCR	D	D:=D−1;
064	302 060 <X>		JNZ	JP7	if D is greater than 0 go to JP7;
067	107	JP6	MOV	B,A	B:=A;
070	043	JP4	INX	H	HL:=HL+1;
071	227		SUB	A	clear accumulator and flags;
072	206		ADD	M	A:=offset value;
073	372 100 <X>		JM	JP8	if most significant bit =1 then go to JP8;
076	200		ADD	B	A:=A+B;
077	311		RET		return;
100	346 177	JP8	ANI	177	mask most significant bit;
102	127		MOV	D,A	D:=A;
103	170		MOV	A,B	A:=B;
104	222		SUB	D	A:=A−D;
105	311		RET		return;

that instant. All tristate register outputs are normally in the high impedance state. To access a register you output the number of the desired channel on an output port. The 7442, IC11, decodes the four least significant bits of the output port to determine which register pair to enable the outputs on; at the same time disabling the inputs of the register pair so that the registers will not be updated while the microprocessor is accessing them. A 0 on the output port places all tristate register outputs in the high impedance state.

Construction Notes

Resistor R4 is used to set the maximum digital value possible. Set all data inputs to the digital to analog converter at +5 V, then set R4 to yield the desired digital value. This sets all analog to digital converter channels simultaneously. If it is required to adjust a single channel's maximum value then a resistor must be added in series with the joystick, such as R15. A value equal to the joystick's internal resistor would cut the full scale digital value in half. Note that the maximum value may also be limited by software as is done in listing 2, but this does not utilize the full displacement of the joystick, as using R15 would.

The +5 V at the joysticks must be regulated and free from noise. Any fluctuations in this voltage will cause fluctuations in the digital value. Depending on your power supply and wiring, it may be necessary to provide a zener diode for on board regulation of the +5 V supply. Also, be sure to use several bypass capacitors.

Software Control

The subroutine of listing 2 will read the digital value from the requested analog to digital conversion channel, set minimum and maximum values, apply a scaling factor, add

or subtract an offset value, and then return the resulting value in the accumulator to the calling program.

A control block must be set up for each analog to digital channel. The address of the control block must be loaded into the HL register pair prior to calling the subroutine. The control block of 5 bytes must be in the following format:

Starting address	Channel number
+1 byte	Minimum value
+2 bytes	Maximum value
+3 bytes	Scale factor
+4 bytes	Offset value

The first byte, channel number, selects the desired pair of tristate registers. It is the binary coded decimal number which when output to the analog to digital converter unit will cause IC11 to enable the desired register pair.

The second byte, minimum value, determines the absolute minimum number that is accepted from the converter. If the value from the converter is smaller than the minimum value it is set equal to the minimum value.

The third byte, maximum value, determines the absolute maximum number that is accepted from the converter. If the value from the converter is larger than the maximum value it is set equal to the maximum value.

The fourth byte, scale factor, determines by what power of two the raw digital data will be scaled. Scaling is accomplished by the new value set equal to the raw data times 2 raised to the power of the scale factor where the scale factor is any value from −127 to +127. This yields the following possible factors (. . . 8, 4, 2, 1, .5, .25, .125, . . .). A one in the most significant bit signifies a negative scale factor.

The fifth byte, offset value, is added to the digital value after the scale factor is applied. It may be any number from −127 to +127. As a two's complement integer, a one in the most significant bit signifies a negative offset.

Conclusions

The final assembly of this circuit, shown in photos 2 and 3, was built into an aluminum housing on a wire wrap board. The circuit can be used to interface any analog voltage signal to a microprocessor. The circuit for interfacing two joysticks to the microprocessor was constructed for about $35, exclusive of the cost of the joysticks. For an additional $10 the circuit could be increased to handle four joysticks.■

Continued from page 16

Popular Electronics Cosmac ELF project, has a possibility of expansion without too much complexity. The processor was obviously designed with the notion that software is cheaper than hardware (sometimes) and the 1802 can be programmed to replace hardware in many ways.

One such way is using a programmable output line as a memory extension address bit. The processor has a Q line output which can be programmed in software to be either high or low. This could be used (properly buffered of course) as an address bit to select a page of memory. This would allow expansion of its address to 17 bits very simply and allow 128 K with very little hardware and also very little software.

I don't intend to be even in the 64 K range for quite some time but those who could use 128 K now can get it easily. Thanks also for the "Beer Budget Graphics" article in the November issue, page 26.

John Pawlicki
6065 Greenwycke Ln
Monroe MI 48161

The same general technique is what is meant by adding bank selection logic to a machine. Several processors have similar opportunities for expansion. For example, the National Semiconductor PACE 16 bit processor has 4 programmable flag outputs – treating those flags as address bits externally results in a total of 20 bits worth of memory address space, or a maximum of 1,048,576 words of memory.

ARE ANY READERS USERS OF SURPLUS DATAPOINT MACHINES?

I've been reading BYTE since the August 76 issue and have enjoyed it quite a lot. It is nice to know there are so many computer freaks out there. The reason I'm writing is that I used to work for Datapoint Corp as a technician. I had a Datapoint 2200 Version II to use for test purposes. It is an 8 bit TTL minicomputer and is fairly fast and powerful. It has a built-in 80 character by 12 line CRT display, a keyboard and a dual cassette deck. Although it has only 16 K of programmable memory, I found it more than adequate with the 2 cassettes with 110 K each, and disk operating software is available. There is a large amount of high level software (including timesharing) available including several excellent diagnostic programs (capable of identifying which memory chip is bad, for example).

They have made over 5,000 of these minis since 1973 and they are available in the used market. I have read of amateur use of the PDP-8, but there has been no mention of the Datapoint. Is there anyone else out there interested in this mini?

Bill Doyle

A COMMENT ON BUG OF THE MONTH #4

The solution to "Bug of the Month #4," in October 76 BYTE, page 41, overlooks an important point. I think it is logically correct after handling the N=2 case and moving statement K=1 to precede the last RETURN as suggested. However, the program (or any program) does not run in a clean environment. Any computer that a FORTRAN compiler or interpreter runs on has a limited integer range. If the value of N to be tested is prime and near the maximum integer that can be represented, the computation I*I will result in integer overflow. This is particularly a problem in FORTRAN as some versions do not give error indications on integer overflow.

As an example, I checked this problem using a version of WATFIV on an IBM 370. Integer overflows do not give an error. The maximum positive integer is 2,147,483,647 (2**31 –1). In the program the value of I is increased until I*I is greater than N, assuming N is prime. The largest value of I which will not overflow when squared is SQRT (2147483647) truncated or 46340. Any prime numbers larger than 46340**2 (2,147,395,600), but still within the integer range, will cause an integer overflow of I and improper termination. I consulted a prime number table and found they don't generally go up to 2 billion; however, there are probably plenty of prime numbers in this category.

Even in the case that an error message occurred on overflow, the routine is still not working correctly. While it would not result in potentially erroneous results, neither has an answer been returned to a perfectly reasonable request. For these large values of N, a possible solution is to simply check for the value of I exceeding 46340 following the I increment. If this occurs, N is then prime.

Unfortunately, this requires an extra operation in the loop and depends upon the computer's integer range. I have not been able to think of a better method.

Keep up the good work. "Bug of the Month" is usually interesting.

Richard Altmaier
POB 2061
Stanford CA 94305

CORRECTIONS FROM BOB MARSH

Three factual errors were included in recent issues of BYTE magazine regarding Processor Technology products:

1. Our Software No. 1 Resident Assembler, Editor Monitor package (referred to in the article as "SYS 8") was a joint development effort between Microtec and Processor Technology. Employees of PTC added many neat features to the original Microtec program in order to produce Software Package No. 1. It was first distributed in July or August of 1975 in the form of well documented source listings. Paper tapes were distributed to many computer clubs free of charge.
   Other companies, including IMSAI and Tarbell, have since made use of Software No. 1 adding minor modifications to suit their IO device requirements. To my knowledge at least six other firms have reproduced Software No. 1 in one form or another, all of them giving PTC and Microtec credit for authorship. (All, that is, except one rather well known "surplus" dealer.) Please note that Microtec receives a small but well deserved royalty on each Software No. 1 we distribute. No other manufacturers are paying such royalties.
   Software No. 1 is currently available from Processor Technology for $14.50 including both source listing and hexadecimal object paper tape or CUTS/BYTE standard cassette.
2. A recent review of our VDM-1 Video Display Module stated delivery as 60 days. In fact VDM-1s have been available "off-the-shelf" since October of 1976. There is no excuse for any of our 40 or so retail distributors to be out of stock for more than a few days. With good planning they should always have VDM-1s, as well as our 2KRO, 3P+S, 4KRA and 8KRA modules, in stock.
3. In your review of the Sol computer system you added $97 for our CUTS audio cassette data interface. The Sol has its own CUTS type interface built in and does not require an additional module for this function. (The CUTS board is primarily used in Altair and IMSAI mainframes.) So the system pricing in your example should be:

Sol-20 kit	$ 995
SOLOS module	100
TV/monitor	150
Cassette recorder	100
8KRA	295
Software	48
	$1688

Bob Marsh
Vice President
Processor Technology
6200 Hollis St
Emeryville CA 94608

COMMENTS ON HOME COMPUTERS: FIND A NEED AND FILL IT

Find a need and fill it! Henry Kaiser built quite a business organization using that phrase as one of his business precepts. And now the development of microcomputers and microprocessors has created a market for home use.

There are many functions in the home that can be carried out by microcomputers because of their unique properties that could not be effectively performed before. They include financial information, inventory of assets, inventory of food and supplies, energy control, recreational games and surveil-

lance for theft and fire. You can probably think of more uses.

A whole new industry is being spawned and it does not detract from other industries because new needs are being created. It can create new job and career opportunities for persons familiar with computer usage.

What should be the marketing effort? Should it be structured like the auto industry with franchisee dealers and new models coming out every year or should it be structured like the radio and television industry with dealers carrying a multiplicity of models? Time will tell.

I would like to see demonstration models placed in places like Newport's Fashion Island or Glendale's Galleria or Los Angeles' Broadway Plaza.

W Donald Pollock
149 S Burlington Apt 2
Los Angeles CA 90057

WANTED: HIGH BANDWIDTH TV MODS

I see many articles and projects on converting televisions to video terminals for use on minis and micros. Unfortunately (for me), these are all set up to generate a 32 character line. I would like to build a terminal using a TV or video monitor that would have 80 or 72 characters per line. Isn't there a kit or some way of bypassing the front end of a TV that will let you get the bandwidth needed? And just how does one figure out the bandwidth that is needed? Does anyone out there have the schematics or logic diagrams for such an adventure? Any help is really welcome.

Joe Heck
12 Enfield St
Jamaica Plain MA 02130

Any authors out there engineering a commercial TV mod which fits this bill? Or is it even possible?

AUTHORS TAKE NOTE: 488 BUS INTERFACE WANTED

I have never written to a magazine, but as I have never enjoyed a publication as much as BYTE, I felt I just had to sit down and let you know how I feel.

I got into programming in a small way a few years ago, with the HP-65 and programming became a new love. I am the Electronics Section Supervisor of the Metrology Laboratory at Puget Sound Naval Shipyard. We have recently acquired an Altair 8800a with 20 K programmable memory, a TTY, 8 K and extended BASIC, and a 4P IO board with 4 ports. We are presently using the Altair for data processing and scientific calculations, but hope to use it in the future as an automatic instrumentation controller.

This brings up a point: I sure would like to see marketed or published a design for an interface from the Altair bus or standard 8 bit parallel ports to the IEEE 488-75 bus. The use of a micro-

computer and a terminal with this interface would give the calibration instrumentation industry an inexpensive and versatile automatic test system.

Bruce O Ferland

PS: Am very excited about machine readable, printed software (bar codes). Hope to see some hardware marketed in the near future.

FREEDOM OF ENTRY

Wilber and Fylstra's sneers at computer professionals in the article "Homebrewery versus the Software Priesthood," October BYTE #14, page 90, are both unnecessary and unsupported. To believe that the industry, its managers, or its programmers *encourages* the present high cost of designing and maintaining software is stupid. Manufacturers normally lose money on systems software that they must develop to sell their machines and want lower costs and greater flexibility reliability (how much does a new release of an operating system cost?) more than anyone. The wide acceptance of such new techniques as top down structured programming, proofs of program correctness, chief programmer teams, and relational file organization indicates the interests of the profession in improving clarity, reliability and productivity.

The demand for computers and programs is very elastic (total spending for these things increases as prices drop). I and other programmers have *more* work than we need. We are happy to have people learn programming.

For those who did not see the article, Wilber and Fylstra accused the profession:

1. of deliberately surrounding computers with an aura of mystery;
2. of protecting their privileged positions by keeping their knowledge to themselves;
3. of regarding their knowledge as sacred and beyond the non-specialist;
4. of being high priests and acolytes of the holy alliance of logic.

All of these charges are false.

In its growth and achievements, the computer industry has been the most dynamic enterprise in this country. We, the computer hobbyists, exist *because* of this success, not in spite of it. Both politically and psychologically, the computer industry is remarkably free of barriers to entry. I have no license or certificate. I have no college degree yet. I was able to get a position as a programmer analyst with no previous experience largely because of my experience in home computing.

Wilber and Fylstra are idiots. They get a minus infinity on BOMB from me.

The December 1976 BYTE was one of the best ever. Keep up the (usually) good work.

Martin Buchanan
2040 Lord Fairfax Rd
Vienna VA 22180

See Mike and Dave's comments in their letter replying to H T Gordon's comments in December. They apply equally here. Would anyone else care to comment?

IS THE SOFTWARE PRIESTHOOD CONCEPT CONSIDERED DANGEROUS?

In his letter concerning the evaluation of microprocessor instruction sets, December 1976 BYTE, page 50, H T Gordon misunderstood the main thrust of our article, "Homebrewery versus the Software Priesthood," October 1976 BYTE, page 90: Of course professional software people *will* always *be* needed by business executives to help evaluate commercial products — that's not our point! We decry only those software people who, like some priests, seek to protect their knowledge of the programmer's art, as opposed to their product. We were concerned with the personal market, not the very different commercial market, and we fundamentally wish to encourage widespread software literacy and free exchange in this personal computing hobby.

Our recognition that there is room for journeyman programmers in the computer business should be clear from our discussion of their relation to the personal computing user. It is important, however, to carefully distinguish the two worlds. In the business world, the programmer's relationship to the client is typically that of an employee or a contractor. By contrast, the firm supplying software for personal use hopes to have a large number of individual customers. The salient distinction is of accountability: The parties to a software transaction are *much* more closely related in the first case than in the second. A commercial client can reasonably expect the software product to suit its intended application, but any individual user of commercially supplied "personal" software represents only a tiny portion of the supplier's intended market. Point one: Individuals wanting personal computers responsive to their own needs must be prepared to program the computer themselves.

On the other hand, if a lot of people know how to program their own computers, then somebody else stands to lose. That somebody else, though, hardly includes everyone paid to write computer programs. While people won't buy something they could easily do better themselves, they are generally happy to

pay for quality merchandise. The essential factor here is the quality of the product. If individual users find it easy to produce fairly good programs, they'll only buy the really good stuff; the only losers will be the producers of mediocre goods. On the other hand, if ignorance is rampant, the less competent programmers can flourish in the personal market. Point two: Only the second rate practitioners stand to gain by a lack of wide scale diffusion of software skills.

Now, most hackers learned what they know for free, and they learned it through personal contact with other hackers. This has almost always happened where they were in close proximity. However, hobbyists, who currently represent almost the entire community of people making personal use of computers, are dispersed geographically. A good system of communication is necessary to bridge the distances. Telecommunications, with its very high transmission speed, can do wonders in helping people share consumerist views of the market as well as actual programs. The telephone brings personal telecommunication into a fantastically large proportion of people's homes, but it has the disadvantage of requiring both parties to a communication to be at home and disposed to communication at the same instant. That's why we proposed a network of "Community Information Exchanges" to serve as buffers to communication. Point three: A CIE net can be of immense utility in dispelling ignorance.

To close the circle, we had no intention to put anybody down; the ideas we're pushing are that a *lot* of people should learn to use computers well. That'll benefit all the good guys; and there's a plausible sounding mechanism by which we can pull it off. We disparage only those who, for whatever reasons, try to prevent it.

Mike Wilber
920 Dennis Dr
Palo Alto CA 94303

David Fylstra
POB 10051
Stanford CA 94305

One point of information, which was not available to Mike or Dave, or Martin or H T Gordon at the time of writing of their respective letters: The results of a recent survey of a random sample of BYTE's 2100 readers out of our list show that they tend to be people with some experience in software with the following numbers:

- *51% indicated prior experience with any large computer system.*
- *58% indicated prior experience with a minicomputer.*
- *79% indicated that they intend to use (52%), or are using (27%), their personal computer system for software development.*

The numbers for various specific professional and business applications goals such as text editing, accounting, or simulation were typically 30% in the "intend" category with 5 to 10% indicating the "actually using" category.

This tends to indicate a significant overlap between professional people and personal computing users so the issue may be a moot one.

WHAT'S AN APPLE?

I am thinking about purchasing an Apple II minicomputer, but before I purchase it I would like to get as much information as possible about it. I wondered if you have heard about this computer or if you had written a product description about it in a past issue. If you could send me any information on it, I would appreciate it very much.

Andrew McNelly
1176 Berkshire Dr
San Jose CA 95125

I saw the prototype in operation on Saturday November 20 1976 in Palo Alto CA in my hotel room when Steve Jobs and Steve Wozniac, Apple's creators, demonstrated it. It will be an excellent product, completely preassembled, available at computer stores nationally as well as by mail order. A 6502, 6 K ROM BASIC, color graphics, completely assembled case and keyboard, 4 K program memory, audio interface, monitor program, etc, all for about $1300. Go to a Homebrew Computer Club meeting and ask people about it. . . CH

HIGH LEVEL DECODING PROBLEM?

Thank you!

As an owner of the SR-52 (and printer), I was delighted to see your articles in the December issue. Programmable calculators, such as the SR-52 and HP-95/97, represent very powerful tools when one must deal with number systems.

I've just about finished a mini Star Trek game. Each time you get a Klingon, the display flashes "BLOOIE" (310078, upside down).

I hope you continue to set aside a small portion of your magazine for these hand held computers.

Meanwhile, my Motorola 6800 evaluation board is waiting in the wings for an RS-232 peripheral.

Tom Handley
New Age Communications
Portland OR

PS: You can reprint this letter if you can decode my terrible writing. (No software provided!) ■

What's New?



At Last! A Phi Deck Tape Mass Storage *System* for the Altair Bus

Recognizing the need for low cost versatile mass storage for the Altair and compatible 8080 based microcomputers, Micro Designs is offering two new digital cassette mass storage systems with up to one megabyte capacity.

According to the manufacturer, an integral part of these ready to use systems is a complete system of file management software which allows the user to manipulate both symbolic and binary files with high level commands.

The Micro Designs Model 100 is a compact single cassette drive which stores up to one half megabyte of data. The random access format of the data on the tape allows programmed access to any single 128 byte record. The data transfer rate is 1000 bytes per second, and the tape may be searched at a rate exceeding 120 inches per second. The dual transport Model 200 puts up to one megabyte of peripheral files on line.

Both units come fully assembled, and ready for immediate use. The interface board plugs into the main frame motherboard connector to attach the mass storage unit to the computer. To bring up the operating system, the user loads a cassette, and transfers control to the ROM on the interface board; all further tape operations are automatic. Status lights inform the user of relevant tape conditions, and hardware error detection is provided. These small table top units sell for $550 (Model 100) and $825 (Model 200). Delivery is quoted as 30 days after receipt of order. Contact Micro Designs Inc, 1175 Colusa Av Berkeley CA 94707.■

At Issue, a Table

We received the following item concerning a new products item in the December 1976 BYTE.

I wish to take issue with the comparison chart given in the "State of the Art Disk Technology" on the SA-400 Minifloppy. Specifically, the specifications on the 3M Minicartridge. When used with the Qantex Model 200 MINI-DRIVE™, the 3M Minicartridge has an unformatted capacity of 336 kilobytes. With the high density option, the Model 200 will provide 676 kilobytes on one 3M Minicartridge. These numbers are computed as follows:

Capacity per track (unformatted)

$$= \text{Length of tape (feet)} \cdot 12 \text{ inches per feet} \cdot \frac{\text{Packing density (bpi)}}{8 \text{ bits per byte}}$$

$$= 140 \cdot 12 \cdot \frac{800}{8}$$

$$= 168\text{ K}$$

For two tracks

Capacity = 336 kilobytes

Thus, your figure of 100 kilobytes is completely erroneous.

The Qantex Model 200 is offered with either a 1 or 2 track head.

Next, let's consider transfer rate, which is computed as follows:

Transfer rate = tape speed (inches/seconds) · packing density (bits/inch)

Transfer rate = 30 ips · 800 bpi

Transfer rate = 24 kilobits per second

Thus, an order of magnitude error in your chart. The Qantex Model 200 with the high density option provides a transfer rate of 48 kilobits per second.

Average access time is usually computed as one half the time required to traverse the media. The Qantex Model 200 provides a high speed mode wherein tape is moved at 90 ips. Access time is computed as follows:

$$\text{Access Time} = \frac{\text{Tape length (ft)} \cdot 12 \text{ in/ft}}{2 \cdot \text{Tape speed (in/sec)}}$$

$$\text{Access Time} = \frac{140 \cdot 12}{2 \cdot 90}$$

$$\text{Access Time} = 9.34 \text{ sec.}$$

The Qantex Model 200 MINI-DRIVE™ with intimate electronics is significantly smaller than indicated, with a physical size of 4 by 4.125 by 3 inches with a companion PC card of 4.5 by 6.5 inches. When packaged in an optional sheet metal enclosure, the complete drive including all PC cards is 4.75 by 4.75 by 7.5 inches.

Incidentally, the Qantex Model 200 configuration, which is equivalent to the type supplied by the SA-400, also costs $390, quantity one.

All things considered, I believe the decision to use a cartridge or disk must be founded upon careful analysis of system requirements. If access time is of key importance, the disk is the obvious choice. If capacity is of key importance, then the cartridge is the obvious choice. Other considerations might be the length of time it takes to validate a data block

just recorded. The rotational latency for the disk is 200 ms. Thus, the system has to wait 200 ms to validate a block just recorded. The Qantex Model 200 with a dual gap head will provide verification 5 ms after the last bit has been recorded. For many applications, this is a critical parameter.

Also to be considered is the MTBF of the two devices. The Model 200 MINI-DRIVE™ has only one motor as opposed to two for the floppy. Aside from the one motor, there is virtually no other mechanism for the Minidrive. The floppy, on the other hand, has the indexing mechanics to impart linear motion to the head positioning mechanism. Shugart's method for indexing is very clever; however, it does not appear to be able to operate in an environment of moderate shock and vibration. Qantex experience in producing the "standard" 3M Cartridge peripheral (AN/USH-26(V) for the Naval Electronics Systems has resulted in a cartridge drive which can operate in severe environments.

Joel A Kramer
President
Qantex Division
North Atlantic Industries Inc
200 Terminal Dr
Plainview NY 11803

Moral of the Story:

When putting in a new product item, the information is supplied by the producer of the product. Now, here is an oblique way of providing a new product item on the Qantex Model 200 MINI-DRIVE—in the way of an interesting letter of protest over a table found in December BYTE. As noted in the Shugart feature in December, the information, in the table on page 87, was "supplied by Shugart." A note of qualification concerning the Philips cassette drive was placed in the text because of the availability of the Phi-Deck and similar low cost drives.

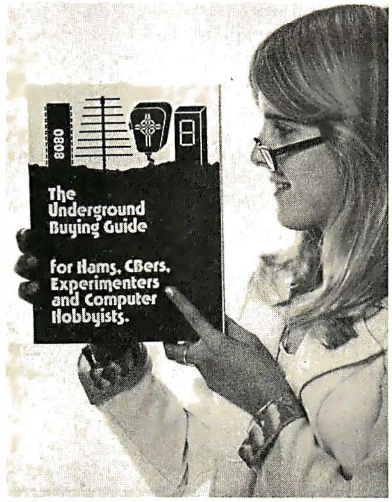
Manufacturing and marketing a product, any product, whether it be a computer, or one's personal services, is a very personal and people oriented activity. Products don't spring forth by magic but represent the creativity of the people working on their design and marketing. This letter emphasizes that fact. . . CH ■

Where to Go to Get Whatever . . .

The following text is taken essentially verbatin from a well written press release . . .

A new directory has just been published that helps radio amateurs, CBers, experimenters and computer hobbyists locate equipment, parts, supplies and services. Over 600 sources of standard and hard to find gear are listed in the handy guide. Many of the 600 sources are mail order firms and many are discounters, too. All are firms that do business with electronics hobbyists.

The first section of the book lists the



firms alphabetically, their complete mailing addresses and phone numbers. Then, a list of the products or services they offer are provided along with key product information, minimum order amounts, shipping charges, etc. You'll find everything from the million dollar mail order firm that handles hundreds of product lines to the weekend garage operation offering a low cost accessory for a microprocessor or Citizen's Band transceiver.

The second section of the book is a breakdown of products and sources in over 200 categories. Under each category is a listing of all firms that sell or manufacture the items cross referenced to the first section. For instance, there are over 25 sources of low voltage (12.6 VDC to 13.8 VDC) power supplies and over 50 sources of digital ICs.

The buying guide contains many prices and sufficient detail that you can make your purchases directly from the book or obtain additional information to make your choice. Catalog prices, if any, are listed.

The last section of the book includes all sources by state so you can buy from the firm nearest you when there are several choices. You'll probably find some local firms that you didn't know existed.

The Underground Buying Guide is available only by direct mail from Peninsula Marketing Services, 12625 Lido Way, Saratoga CA 95070. The price is $5.95 plus $.55 postage and handling. Californians add $.39 sales tax. Money-back guarantee within 10 days if you are not completely satisfied. ■

Attention Commercial and Industrial Users of the 8080

muPro Inc, 424 Oakmead Pky, Sunnyvale CA 94086, has just announced what may be one of the best 8080 oriented assemblers to come to market. This is the BSAL-80 assembler, a "block structured assembly language" which comes with a relocating and linking loader. Finally, someone in the microprocessor world has gotten around

to implementing some of those nice things which systems programmers have grown accustomed to on the bigger minicomputer and large scale computers! This product, according to the press release, "allows the user to write programs in a high level language syntax while retaining the flexibility, program size and execution speed of assembly language. The ability to utilize any of the 8080 machine instructions and to control the use of the architectural features of the 8080 is maintained."

Since the output is truly relocatable and has linkage information, the programmer is able to develop truly modular programs. The company also has available a line number oriented editor program and a loader program to go with the assembler. The product is definitely aimed at commercial users, since its price is well out of the range of the individual user on a tight budget: The BSAL-80 assembler with BSAL-80 relocating/linking loader are available together for $975 in 8080 resident form: the BSAL-80 text editor is available for $350. The text editor, assembler and loader are available as a package for $1250 and a FORTRAN IV cross assembly version is available for $1250. The 8080 resident versions are provided free of charge with the purchase of the muPro-80, muPro-80E or muPro-80ED hardware and software development systems manufactured by the firm. Delivery of the software is quoted as immediate.■

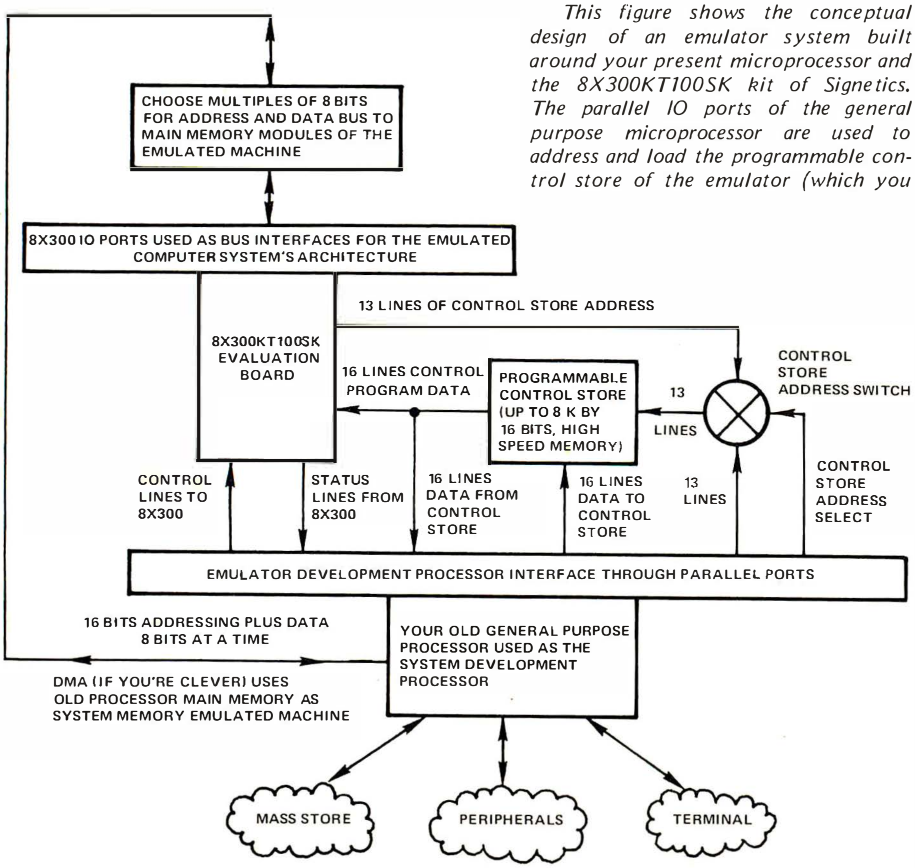
Cogitate then Emulate with This Bipolar Controller . . .

The new Signetics 8X300 bipolar microprocessor device is now available in a single board design evaluation kit intended to titillate the fancies of the hardware designer . . . but guaranteed to find its way into a few homebrew experimenters' hands as one of the cheapest, fastest and easiest routes to a high performance microprogrammable emulator for existing or experimental processor architectures. At $299 it's hard to argue with the features of this kit:

- 250 ns bipolar 8X300 processor. This processor handles 8 bits at a time with a read-modify-write cycle of 250 ns. (Yes, that's four instructions per microsecond!)
- 256 bytes of high speed working data storage. (In the use of this board as a microprogrammed emulator, this becomes the area used for the control data and general registers of the machine you emulate. If you're crazy enough to want to emulate a 360, for example, allocate 64 of these bytes as the 16 general purpose registers and another 32 bytes for the four floating point registers and use the remainder for control registers and pointers within the emulator.)
- Four IO ports implemented to interface external devices. (You'd use these ports to drive the address and data buses of the emulated computer system.)
- System development software in PROM to aid you in utilizing the board.
- 13 bit address bus and 16 bit data bus for the microprogram memory used to drive the 8X300. (This should be more than enough control store to build the aforementioned 360 emulator. For a microprogramming project you'd want to add up to 8 K by 16 bits of dual port programmable memory to this bus.)
- Diagnostic and instructional controls which include a WAIT mode to allow single step operation, oneshot instruction jamming, ability to change or examine internal registers, etc.

Contents of the kit (hardware) include an 8X300 processor, eight 82S116 programmable memories for the data store, two 82S115 512x8 PROMs with the systems software for evaluation use, miscellaneous TTL parts, the printed

How to Use the 8X300 Controller as an Emulator **notes by Carl Helmers, Editor**



This figure shows the conceptual design of an emulator system built around your present microprocessor and the 8X300KT100SK kit of Signetics. The parallel IO ports of the general purpose microprocessor are used to address and load the programmable control store of the emulator (which you have to assemble yourself from high speed chips or run the 8X300 at less than its full rated speed). Assuming that you start with a complete computer system which includes assembler or high level language, you write the software of a microassembler in order to create the emulation programs conveniently prior to loading the control store. You use the IO ports of the evaluation card (plus additional ones if necessary) to define the address and data bus structure of the machine you're emulating. If you're clever, you make this output of the 8X300 treat your old microprocessor's memory as its own via the DMA trick, but for initial testing it is probably better to dedicate a small amount of memory (perhaps 4 K bytes) exclusively to the emulated machine to avoid blowups due to wild programming of undebugged machine instructions. Through the control and status interfaces you tack onto the evaluation board kit, you make the emulated machine treat the old machine and its peripherals as its main IO devices, so that programs working in the new architecture can at least talk to you. The result of all this cogitation and wiring will be a microprogrammable computer architecture experimental rig which will be the envy of many an industrial laboratory or university computer science department — yet still at a cost within the advanced experimenter's budget.■

circuit, complete manual and assembly instructions. Signetics is located at 811 East Arques Av, Sunnyvale CA 94086, and the 8X300KT100SK is available from Signetics distributors.■

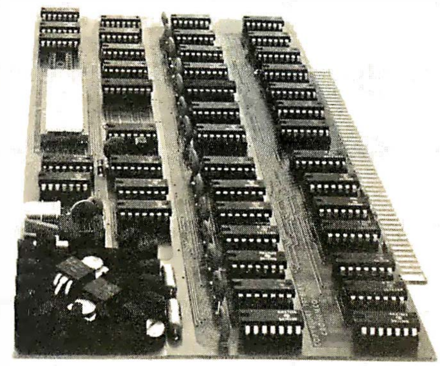
What Makes the Z-1 Tick?

Cromemco has forwarded this picture of Harry Garland's Z-80 processor card which is what makes their new Z-1 computer "tick." According to Cromemco, they have an arrangement with Zilog to obtain a selected version of the Z-80 processor which can operate with a 4 MHz clock. Yet the card remains compatible with the Altair bus which is available from numerous manufacturers.

This processor card design has a crystal controlled 4 MHz clock which can drive the processor at either 4 MHz or 2 MHz depending upon a switch selected option. The use of memory wait states enables the board to operate with mixes of fast and slow memory in the event that an older system is being upgraded to the 4 MHz clock rate.

An interesting feature which will prove most useful to those people who purchase the Cromemco Bytesaver EROM card (or its equivalent) in order to build permanent systems software loads is the new Cromemco Z-80 processor card's power on restart option which allows selection of an automatic restart vector to any 4 K boundary in memory address space. Thus if you put your monitor in EROM up at hexadecimal address F000, this board lets you set up an automatic restart jump to your monitor whenever you turn on the power (or if you're a true hacker, when you simulate power on with your own restart button).

This processor is available either in kit or in assembled form at prices of $295 and $395 respectively. Delivery is quoted as 15 to 30 days ARO (after



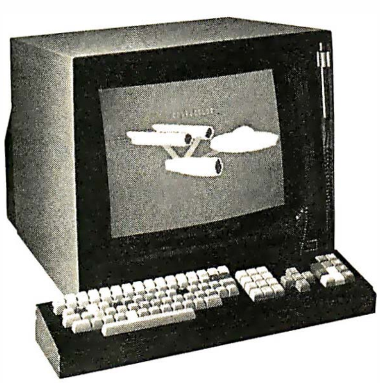
receipt of order). Cromemco also provides a Z-80 monitor, with complete documentation including source code and paper tape object code. Also available according to the press release is a Z-80 assembler and BASIC interpreter. Cromemco is located at 2432 Charleston Rd, Mountain View CA 94043.■

A Matter of Form

We recently received a pad of coding forms for those who work in assembly or machine language, designed and sold by Walton Electronics. The forms are bound together in pads of 50 sheets and are formatted to accept code for the more popular microprocessors. Columns include: address, code, label, instruction and notes. Code can be written in either octal or hexadecimal with up to 3 bytes per line in regular assembler format. The lines are spaced to permit coding from a pica typewriter.

These forms make hand assembly easier and neater which helps eliminate errors. The pads sell for $1.95 each postpaid. Quantity discounts are available. Order from Walton Electronics, POB 503, Bethany OK 73008, or check your nearest computer store.■

Explore the Universe of Color



Compucolor Corp, Norcross GA 30071, announced plans in December 1976 to begin marketing a new 8 color personal computer, the Compucolor 8001, in early December. According to the press release, the Compucolor 8001 is a stand alone CRT and microcomputer with both computation and graphics capabilities.

It is programmed to handle simple or complex tasks, from color graphics and income tax records to checkbook balancing, education instruction, tutoring and a unique variety of computer games. The unit features BASIC language, a 19 inch display screen, keyboard and tape memory. Options are also available.

The Compucolor is being marketed through retail computer stores nationwide, and no price was quoted with the press release.■

Comments on a Prototyping Bus

Webb Simmons
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San Diego CA 92111

(See December 1976 BYTE, page 128.)

This concerns the proposal for a universal prototyping bus structure by David Washburn.

Mr Washburn raises some interesting points, none of which raise objections from me; however, when we dream let us dream boldly. It is not boldness to increase the address bus width from 16 bits to 18 bits. It is not boldness to replace the pseudostandard bus with an 88 connection bus.

A truly bold step for the address bus is to immediately go to 24 bits (3 bytes). The processor board can have two 8 bit registers, loaded by IO instructions (but it does not matter how they get loaded), to supply the upper 8 bits of an address. The choice of which upper register to use would be based upon whether it is an instruction fetch. *[Not necessarily possible to determine with any processor chip . . .* CH*]* In this way instructions and data can be arbitrarily far apart. The actual loading of the upper address register should be deferred by one instruction time to allow for a jump into the newly selected memory block. Many variations on this theme are possible and none would be binding upon any user. Merely allow 24 bits and let each person do his/her own thing.

Similar reasoning suggests 24 bits for the data bus. *[But why not go all the way to 32 ? ? ?* CH*]* A person with true 16 bits of data may wish to use a Hamming code for error correction as well as (in lieu of) simple error detection. A 21 bit field is required to correct a one bit error in 16 bits (see the Data General description of their Eclipse computer). Once again a person may either use the extra bits or ignore them.

I rather like the thought of multiple inexpensive connectors, but why stop at two?

Some Comments on the Universal Bus Idea

M Faiman
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University of Illinois at Urbana-Champaign
Urbana IL 61801

David Washburn's comments in the December issue of BYTE on a universal bus structure are well taken. We ran into the problem he describes a couple of years ago when we started to experiment with microprocessors in our department. Every microprocessor, as your readers well know, has its own external signal configuration and protocol which all other devices — memory boards, IO interfaces, etc, must match in order to form a working system. Changing processors, even if they cost a mere $25, necessitates a costly redesign of all the associated device interfaces. Since there are typically many of the latter for only one of the former, this is obviously an expensive and, in most instances, impractical business.

Our solution, after studying the characteristics of the popularly available and projected microprocessors, was to design our own Modular Unified Microprocessor System — MUMS (1, 2, 3, 4). This system has undergone two design iterations since its inception, and its chief characteristics may be summarized as follows:

1. The hardware utilizes a fairly simple, uniform bus structure that is processor independent. There is one microprocessor per bus, and it and all other devices intercommunicate via a small set of generic signals (see item 5 below).
2. The bus signal protocol is chosen so that the most numerous modules in a system require only the simplest, ie: least expensive, interfaces.

Use three connectors or even four. When a user has no need for the extra connectors they can be omitted from the mother board. The standard board size might increase somewhat but the extra square inches will not be very expensive.

The 3 bit "speed code" set by each memory board seems to have no advantage over a one bit "data ready" signal from memory. Unless and until the data is truly ready the processor can do nothing sensible anyway. Many computers already allow for asynchronous memory with an indefinite wait for data ready, so this in not new.

Concerning standard peripheral device numbers, why not define them in the range from a low of zero to a high of 255? Then allow anyone to append one or two upper bytes to this low byte of standard assignments. The upper byte (or bytes) could be set with jumpers or dip switches. This will allow the spirit of standard device assignments and still let a user put them where he wishes.

For multiple processors (eg: 2) let us not overlook the possibility of Y shaped memory in which each processor gets its instructions from its own branch of the Y without conflicts with the other processor. For data the processors can share the common branch and most of the time both processors can run at near full speed.■

---

3. To sidestep the spread in timing requirements of different processors the mode of communication on the bus is asynchronous. A particular advantage of this is that memory boards of differing access/cycle times can be used in the same system. (There is no need for the "speed code" number that Mr Washburn describes.)
4. Multiprocessing is accomplished with the aid of a TIE module and, optionally, a COM-UNIT. The former plugs into any MUMS bus and appears to the processor as a DMA device. From its other end a 4 wire line (10 MHz serial) can talk to a similar module on another bus for dual processor activity, or to the COM-UNIT – in process of design right now – which will handle communication between up to 16 processors.
5. The bus is physically implemented on a 72 pin connector (DEC compatible), as shown in the figure. Of these, the DATA, ADDRESS and POWER lines are self-explanatory. The others have mnemonic names, as follows:

Expansion — Component Side of Card / Foil Side of Card

Component Side	Pin	Pin	Foil Side	Group
BD15	1A	2A	BD7	DATA
BD14	1B	2B	BD6	
BD13	1C	2C	BD5	
BD12	1D	2D	BD4	
BD11	1E	2E	BD3	
BD10	1F	2F	BD2	
BD9	1H	2H	BD1	
BD8	1J	2J	BD0	
x	1K	2K	x	
x	1L	2L	x	
BA15	1M	2M	BA7	ADDRESS
BA14	1N	2N	BA6	
BA13	1P	2P	BA5	
BA12	1R	2R	BA4	
BA11	1S	2S	BA3	
BA10	1T	2T	BA2	
BA9	1U	2U	BA1	
BA8	1V	2V	BA0	
GND	3A	4A	GND	POWER
GND	3B	4B	GND	
+5	3C	4C	+5	
+12	3D	4D	+12	
−12	3E	4E	−12	
x	3F	4F	x	
$\overline{RST}$	3H	4H	$\overline{ACK}$	MEMORY (CONTROL)
x	3J	4J	x	
$\overline{RAV}$	3K	4K	$\overline{WAV}$	
x	3L	4L	x	
$\overline{WHD}$	3M	4M	$\overline{WLD}$	
$\overline{DGI}$	3N	4N	$\overline{DGO}$	DMA (CONTROL)
$\overline{I/O}$	3P	4P	$\overline{DMR}$	
ISN	3R	4R	$\overline{IVV}$	INTERRUPT (CONTROL)
IGI	3S	4S	IGO	
IA3	3T	4T	$\overline{IR3}$	
IA2	3U	4U	$\overline{IR2}$	
IA1	3V	4V	$\overline{IR1}$	

MUMS Bus — Signal Layout

- $\overline{RST}$ — Power on reset
- $\overline{RAV}$ — Read Address Valid (from processor DMA device to memory or IO device register)
- $\overline{WAV}$ — Write Address Valid (similarly)
- $\overline{ACK}$ — Acknowledge (opposite direction)
- $\overline{WLD}$ — Write Low Data byte
- $\overline{WHD}$ — Write High Data byte
- $\overline{DMR}$ — DMA device Request
- DGI/DGO — DMA Grant In/Out (daisy chained signal)
- IO — Used in conjunction with appropriate memory control signals to access an IO page.
- ISN — Interrupt Sync (processor generated)
- $\overline{IRi}$ — Interrupt Request for level i (i = 1,2,3)
- IAi — Interrupt Acknowledge for level i
- IGI/IGO — Interrupt Grant In/Out (daisy chained signal)
- $\overline{IVV}$ — Interrupt Vector Valid (device to processor)

It is obviously beyond the scope of this letter to describe timing relationships in detail, but the interested reader may find particulars in references 2 and 4 below. ■

REFERENCES

1. Faiman, M: Modular, Unified Microprocessor System (MUMS), ACM Computer Science Conference Abstracts, page 19, February 1976.
2. Catlin, R W: MUMS: A Modular, Unified Microprocessor System, (50 pages, Technical Report UIUCDCS-R-76-809, University of Illinois, Urbana-Champaign), IEEE Computer Society Repository #R76-245.
3. Faiman, M, Catlin, R W and Weaver, A C: A Modular, Unified Microprocessor System (MUMS), Proceedings of the IEEE DISE Workshop on Microprocessors, pages 1-5, Colorado State University, August 1976.
4. Faiman, M, Weaver, A C and Catlin, R W: MUMS — A Reconfigurable Microprocessor Architecture, *Computer*, January 1977.

What's New?

Computer Power & Light

Gene Morrow, president of Computer Power & Light, a computer store located at 12321 Ventura Blvd, Studio City CA 91604, has sent along a brochure describing his firm's packaged 8080 processor system. The Computer Power & Light COMPAL-80 computer is a fully assembled system for homes and small businesses, which includes the following main features:

- 8080A processor
- audio tape serial interface port
- Teletype or RS-232 serial port
- 12 K programmable memory
- 16 line by 64 character video display with full ASCII character set and graphics
- 9 inch high resolution monitor
- ASCII keyboard with capacitance switch mechanisms
- case and cabinetry with cooling phan, chassis connectors for interfaces, "turn key" configuration
- PROM monitor to eliminate the need of a costly front panel
- 10 K extended BASIC including formatted PRINT, double precision, all transcendental functions, etc.

The price on the above package of features is quite reasonable — for $1863 you get a completely assembled system which can be viewed and examined in Gene's store. Gene's press release claims that several systems already have been delivered including one which is in use at Mt St Mary's College in Los Angeles as part of a computer programming curriculum, another which is being used to keep track of inventory in a retail store in Santa Barbara, and another in an industrial laboratory. For more information, contact Gene at the store. ■

A New Version of SC/MP

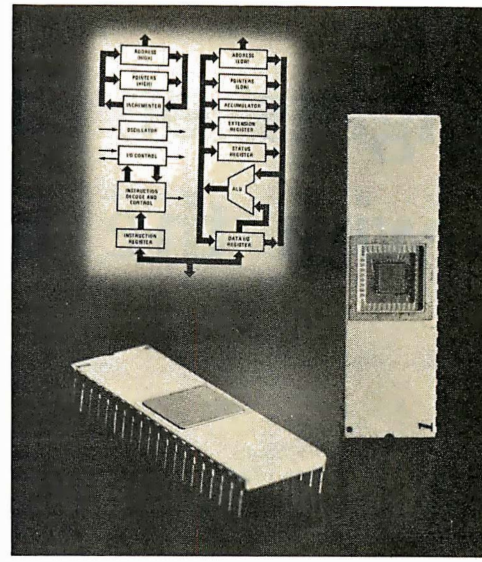
National Semiconductor has now introduced a new version of the SC/MP processor (see Robert Baker's article in September 1976 BYTE, page 76). This newer version is implemented with a faster NMOS technology with the following essential points of improvement:

- Twice as fast in execution (3.58 or 4.0 MHz on chip crystal)
- One quarter of the power requirements (200 mW versus 800 mW)
- Compatibility with the previous product
- Single power supply

According to the press release, this new version is being sampled from the factory at $17.76 for single quantities and in 1977 the production quantities of 1000 or more will sell "significantly below $10 each" when it becomes available in a plastic package. National Semiconductor also plans to have available a retrofit kit for present owners of SC/MP kits, which will allow conversion to the new processor. The price for this product is not yet announced.

This is the kind of processor which rapidly becomes a commodity part, and can thus be buried into all manner of dedicated application products with appropriate read only memory software designs and special purpose peripheral hardware. For an example of such dedicated products, consider the dedicated electronic music synthesizer module: Hypothesizing a $2 to $5 price for a plastic package version of this computer, using perhaps 1 or 2 K of 2708 storage for control programs, and perhaps 1 K or so of programmable memory for parameters, it should be possible to engineer an inexpensive stand-alone music synthesizer module which will sit on a computer table and take orders through a high speed serial port and RS-232 level receivers.

National Semiconductor is located at 2900 Semiconductor Dr Santa Clara CA 95051. National Semiconductor parts and products are available through most nationwide electronic distributors.■



Floppy Disk Controller
And a Hint about a Future Article

NEC Microcomputers Inc, Five Militia Dr, Lexington MA 02173, has a pair of the most advanced LSI devices available for peripheral control in microprocessor systems. This pair consists of the uPD372D floppy disk controller chip (now available at $54 in quantities of 1 to 24) and the uPD371D cassette controller chip (also available, in quantities of 1 to 24 quoted at $48). Both these items are available from a nationwide network of distributors, which in New England includes Harvey Electronics, Semiconductor Specialists and Sterling Electronics. Tim Schoechle, of the Technical Staff for Microprocessors of NEC, sent along the latest technical manual on the floppy disk controller chip, for use as a reference in editing a forthcoming article by Ira Rampil which reviews both of these controllers.

When you buy one of these chips, you get a fixed purpose processor which is customized to the job at hand. As described in the 68 page uPD372D disk controller manual (dated December 3 1976, which we understand was written by Tim), the chip takes care of all the housekeeping and formatting requirements at the hardware level needed to create floppy disk records with IBM 3740 format, Shugart Minifloppy format, etc. It also generates and checks cyclic redundancy characters, can be synchronized with address marks or physical indices (so called "hard sectors"), and will handle up to four floppy disk drives through separate select lines. Furthermore, it has the capacity to overlap input and output control of two separate drives. Taking into account differences in hardware, the track to track stepping rate and stepping pulse width outputs are programmable, as is the sector size and data rate. A list of 13 drives with which the chip is compatible is given by manufacturer and model number. More detailed information will have to wait for Ira's article — but for the engineers or homebrewers who can't wait, the information is available from NEC or its representatives: Ask for the "uPD372D LSI Floppy Disk Controller Chip User's Manual."■

Flights of Fancy with the Enterprise

David Price
3901 Victoria Ln
Midlothian VA 23113

The main objective of this version of the Star Trek game is to destroy all of the Klingon battle cruisers within 30 stardates. The Klingons and starbases are randomly positioned within a simulated galaxy. To help you better visualize this galaxy we use quadrant sector notation.

The galaxy is divided into a matrix of 8 by 8, or 64, quadrants. Each quadrant is further subdivided into an array of 8 by 8 sectors. The United Space Ship Enterprise, of which you are captain, has been assigned to seek out and destroy all of the Klingon invaders. You have at your disposal a bristling array of sophisticated weaponry including phasers, photon torpedoes, and an onboard computer, which are triggered by

Once upon a time there was Star Trek. During its brief but eventful life as a television series it not only won acclaim from within the science fiction community, but was also hailed by the popular media as one of the first truly intelligent shows on television. It attracted an entirely new type of audience to science fiction including many from the computer crowd. By showing us glimpses of a distant future, it allowed us to take a more objective look at the present. Star Trek now survives only in rerun form and in the games of computer people. Those computer people who happen to be Trekkies have adopted the Star Trek theme as their own. Everybody under the sun has been programming games based loosely on Star Trek. These games have evolved into some of the most complex computer games ever written. Yet, lurking beneath this complexity lies a startling amount of realism.

Listing 1: The Star Trek program, expressed in BASIC. For notes on conversion to Altair BASIC see the text. This version requires 9382 bytes of work space for the program text, 161 matrix elements, and 46 bytes of character string space. The approximate total size requirement is thus 10 K bytes, plus the size of the BASIC interpreter itself. Using a 12 K extended BASIC interpreter, this program would thus require approximately 22 K of programmable memory in a typical microcomputer system. Hurrah for the 16 K chips!

```
STTR

10  REM *************** STAR TREK ******************
20  REM ****                                      ****
30  REM ****      STTR: SPACE WAR SIMULATION      ****
40  REM ****                                      ****
50  REM ****     PROGRAM BY DAVID PRICE           ****
60  REM ******************************************
70  DEF FNA(X)=INT(X*RND(1)+1)
80  DIM G[8,8],Z$[15],C$[6],X$[24]
90  T0=T=(FNA(20)+20)*100
100  E=3000
110  P=15
120  S=0
130  X$="------------------------"
140  DEF FND(D)=SQR((K[I,1]-S1)^2+(K[I,2]-S2)^2)
150  Q1=Q2=S1=S2=FNA(8)
160  MAT C=CON[9,2]
170  C[2,1]=C[3,1]=C[4,1]=C[4,2]=C[5,2]=C[6,2]=-1
180  C[1,1]=C[3,2]=C[5,1]=C[7,2]=C[9,1]=0
190  MAT D=ZER[6]
200  B9=K9=0
210  FOR I=1 TO 8
220  FOR J=1 TO 8
230  K3=B3=0
240  IF RND(1)<.8 THEN 270
250  K3=FNA(3)
260  K9=K9+K3
270  IF RND(1)<.96 THEN 300
280  B3=1
290  B9=B9+1
300  S3=FNA(5)
310  G[I,J]=K3*100+B3*10+S3
320  NEXT J
330  NEXT I
340  IF K9=0 OR B9=0 THEN 200
350  GOTO 3570
360  IF Q1 >= 1 THEN 380
370  S1=Q1=1
380  IF Q1 <= 8 THEN 400
390  S1=Q1=8
400  IF Q2 >= 1 THEN 420
410  S2=Q2=1
420  IF Q2 <= 8 THEN 440
430  S2=Q2=8
440  X=G[Q1,Q2]/100
450  K3=INT(X)
460  B3=INT((X-K3)*10)
470  S3=G[Q1,Q2]-((B3*10)+(K3*100))
480  IF K3=0 THEN 520
490  PRINT "COMBAT AREA","CONDITION RED"
500  IF S>(K3*100) THEN 520
510  PRINT "  SHIELDS DANGEROUSLY LOW"
520  MAT K=ZER[3,3]
530  MAT Q=ZER[8,8]
540  Q[S1,S2]=1
550  FOR I=1 TO K3
560  GOSUB 3500
570  Q[R1,R2]=2
580  K[I,1]=R1
590  K[I,2]=R2
600  K[I,3]=200
610  NEXT I
620  IF B3=0 THEN 650
630  GOSUB 3500
640  Q[R1,R2]=4
650  FOR I=1 TO S3
660  GOSUB 3500
670  Q[R1,R2]=3
```

your direct orders. To utilize the facilities of the Enterprise you enter simple numerical commands. Figure 1 shows the flowchart for the initialization of the variables used in the program and the first quadrant set up. The flowchart also indicates on what lines of the program the various operations take place.

The Command Set

Figure 2 shows the flowchart for entering commands to the program. The commands are numbers which are tested by the program to determine what to do.

Command **0** places you in control of the warp engines which are used to propel the Enterprise from one location to another. You are first asked for the direction in which you wish to travel. The trajectory angles are arranged on a circular vector as shown in figure 3.

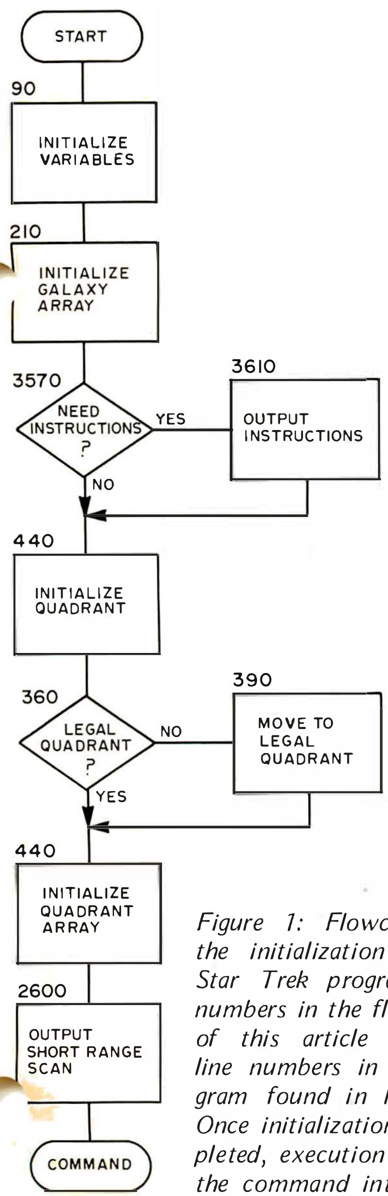


Figure 1: Flowchart for the initialization of the Star Trek program. The numbers in the flowcharts of this article refer to line numbers in the program found in listing 1. Once initialization is completed, execution flows to the command interpreter.

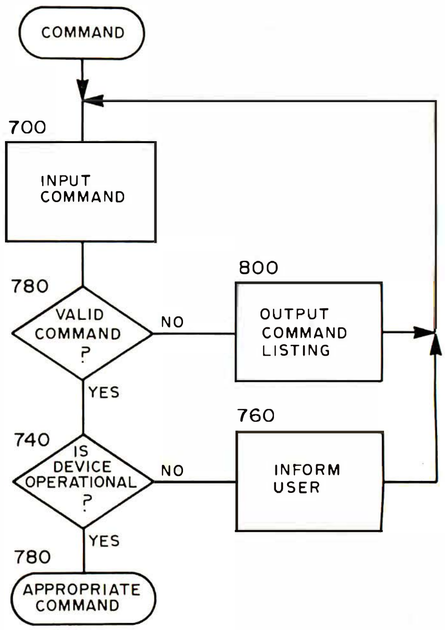
Listing 1, continued:

```
680  NEXT I
690  GOSUB 2600
700  PRINT "COMMAND:";
710  INPUT A
720  IF A<1 OR A>5 OR A#INT(A) THEN 780
730  R1=A+1
740  IF D[R1] >= 0 THEN 780
750  GOSUB 3420
760  PRINT Z$;" NOT OPERATIONAL"
770  GOTO 700
780  GOTO (A+1) OF 890,1520,1640,1800,2200,3010,3550
790  PRINT
800  PRINT "0=SET COURSE";TAB(20);"4  3  2"
810  PRINT "1=LONG RANGE SCAN";TAB(21);"\ ^ /"
820  PRINT "2=PHASER CTRL";TAB(22);"\^/"
830  PRINT "3=TORPEDO CTRL";TAB(18);"5 ------- 1"
840  PRINT "4=SHIELDS";TAB(22);"/^\"
850  PRINT "5=LIBRARY COMPUTER";TAB(21);"/ ^ \"
860  PRINT "6=RESIGNATION";TAB(20);"6  7  8"
870  PRINT
880  GOTO 700
890  PRINT "COURSE (1-9):";
900  INPUT C1
910  IF C1<1 OR C1 >= 9 THEN 700
920  PRINT "WARP FACTOR (0-8):";
930  INPUT W1
940  IF W1 <= 0 OR W1>8 THEN 700
950  IF D[1] >= 0 OR W1 <= .5 THEN 980
960  PRINT "ENGINES ARE DAMAGED, MAXIMUM SPEED= WARP .5"
970  GOTO 920
980  IF E-(W1*8)>0 THEN 1030
990  IF S<1 THEN 2470
1000 PRINT "YOU ONLY HAVE";E;"UNITS---SUGGEST YOU CROSS-CIRCUIT"
1010 PRINT "FROM SHIELDS, WHICH HAVE";S;"UNITS"
1020 GOTO 700
1030 FOR I=1 TO 6
1040 IF D[I] >= 0 THEN 1060
1050 D[I]=D[I]+1
1060 NEXT I
1070 IF FNA(10)#5 OR W1<2 THEN 1120
1080 R1=FNA(6)
1090 D[R1]=D[R1]-FNA(5)
1100 GOSUB 3420
1110 PRINT LIN(1),"DAMAGE CTRL REPORTS '";Z$;" DAMAGED.'",LIN(1)
1120 N=INT(W1*8)
1130 Q[S1,S2]=0
1140 X=S1
1150 Y=S2
1160 C2=INT(C1)
1170 X1=C[C2,1]+(C[C2+1,1]-C[C2,1])*(C1-C2)
1180 X2=C[C2,2]+(C[C2+1,2]-C[C2,2])*(C1-C2)
1190 FOR I=1 TO N
1200 S1=S1+X1
1210 S2=S2+X2
1220 IF S1<1 OR S1>8 OR S2<1 OR S2>8 THEN 1360
1230 IF Q[INT(S1),INT(S2)]=0 THEN 1270
1240 S1=S1-X1
1250 S2=S2-X2
1260 GOTO 1280
1270 NEXT I
1280 S1=INT(S1)
1290 S2=INT(S2)
1300 Q[S1,S2]=1
1310 E=E-N
1320 IF W1<1 THEN 690
1330 T=T+1
1340 IF T>T0+30 THEN 2500
1350 GOTO 690
1360 X=Q1*8+X+X1*N
1370 Y=Q2*8+Y+X2*N
1380 Q1=INT(X/8)
1390 Q2=INT(Y/8)
1400 S1=INT(X-Q1*8+.5)
1410 S2=INT(Y-Q2*8+.5)
1420 IF S1>0 THEN 1450
1430 Q1=Q1-1
1440 S1=8
1450 IF S2>0 THEN 1480
1460 Q2=Q2-1
1470 S2=8
1480 T=T+1
1490 E=E-N+5
1500 IF T>T0+30 THEN 2500
1510 GOTO 360
1520 PRINT X$[1,17]
1530 FOR I=Q1-1 TO Q1+1
1540 MAT N=ZER[3]
1550 FOR J=Q2-1 TO Q2+1
1560 IF I<1 OR I>8 OR J<1 OR J>8 THEN 1580
1570 N[J-Q2+2]=G[I,J]
1580 NEXT J
1590 PRINT  USING 1630;N[1],N[2],N[3]
1600 PRINT X$[1,17]
1610 NEXT I
1620 GOTO 700
1630 IMAGE ": ",3(3D," :")
1640 IF K3=0 THEN 2350
1650 PRINT "ENERGY AVAILABLE=";E
1660 PRINT "NUMBER OF UNITS TO FIRE:";
1670 INPUT X
1680 IF X<1 THEN 700
1690 IF E-X<0 THEN 1660
1700 E=E-X
1710 FOR I=1 TO 3
1720 IF K[I,3]=0 THEN 1780
1730 H=INT(X/K3/(FND(0)))
1740 K[I,3]=K[I,3]-H
1750 PRINT H;"UNIT HIT ON KLINGON"
1760 IF K[I,3]>0 THEN 1780
1770 GOSUB 2050
1780 NEXT I
```

Listing 1, continued:

```
1790  GOTO 2030
1800  IF P>0 THEN 1830
1810  PRINT "ALL PHOTON TORPEDOES EXPENDED"
1820  GOTO 700
1830  PRINT "TORPEDO COURSE (1-9):";
1840  INPUT C1
1850  IF C1<1 OR C1 >= 9 THEN 700
1860  C2=INT(C1)
1870  X1=C[C2,1]+(C[C2+1,1]-C[C2,1])*(C1-C2)
1880  X2=C[C2,2]+(C[C2+1,2]-C[C2,2])*(C1-C2)
1890  X=S1
1900  Y=S2
1910  P=P-1
1920  PRINT
1930  X=X+X1
1940  Y=Y+X2
1950  IF X<1 OR X>8 OR Y<1 OR Y>8 THEN 2180
1960  IF Q[INT(X),INT(Y)]=0 AND Q[INT(X+.5),INT(Y+.5)]=0 THEN 1930
1970  FOR I=1 TO 3
1980  IF INT(X)=K[I,1] AND INT(Y)=K[I,2] THEN 2020
1990  IF INT(X+.5)=K[I,1] AND INT(Y+.5)=K[I,2] THEN 2020
2000  NEXT I
2010  GOTO 2120
2020  GOSUB 2050
2030  GOSUB 2370
2040  GOTO 700
2050  K[I,3]=Q[K[I,1],K[I,2]]=0
2060  PRINT "***KLINGON DESTROYED***"
2070  K3=K3-1
2080  K9=K9-1
2090  IF K9=0 THEN 2550
2100  G[Q1,Q2]=G[Q1,Q2]-100
2110  RETURN
2120  IF Q[INT(X),INT(Y)]#3 THEN 2150
2130  PRINT "YOU CAN'T DESTROY STARS, SILLY!"
2140  GOTO 2180
2150  PRINT "***STARBASE DESTROYED***"
2160  PRINT "YOU ARE HEREBY RELIEVED OF DUTY!!  CONGRATULATIONS!"
2170  GOTO 2530
2180  PRINT "TORPEDO MISSED"
2190  GOTO 2030
2200  PRINT "ENERGY AVAILABLE=";E+S
2210  PRINT "NUMBER OF UNITS TO SHIELDS:";
2220  INPUT X
2230  IF X<0 THEN 700
2240  IF E+S-X<0 THEN 2210
2250  E=E+S-X
2260  S=X
2270  GOTO 700
2280  PRINT LIN(1);"DEVICE","STATE OF REPAIR"
2290  FOR R1=1 TO 6
2300  GOSUB 3420
2310  PRINT Z$,D[R1]
2320  NEXT R1
2330  PRINT
2340  GOTO 700
2350  PRINT "SHORT RANGE SENSORS REPORT NO KLINGONS IN THIS QUADRANT"
2360  GOTO 700
2370  IF C$="DOCKED" THEN 2460
2380  IF K3=0 THEN 2460
2390  FOR I=1 TO 3
2400  IF K[I,3]=0 THEN 2450
2410  H=INT(K[I,3]/FND(0)+1)
2420  S=S-H
2430  PRINT H;"UNIT HIT ON ENTERPRISE"
2440  IF S<0 THEN 2520
2450  NEXT I
2460  RETURN
2470  PRINT "**FATAL ERROR**"
2480  PRINT "THE ENTERPRISE IS DEAD IN SPACE, AND MUST BE EVACUATED!!"
2490  GOTO 2530
2500  PRINT LIN(1),"IT IS STARDATE";T
2510  GOTO 2530
2520  PRINT LIN(1);"    ***THE ENTERPRISE HAS BEEN DESTROYED***"
2530  PRINT LIN(1),"THE FEDERATION WILL BE CONQUERED!!!"
2540  GOTO 3560
2550  PRINT
2560  PRINT "THE LAST KLINGON BATTLE CRUISER HAS BEEN DESTROYED!!"
2570  PRINT "THE FEDERATION HAS BEEN SAVED !!"
2580  PRINT
2590  GOTO 3560
2600  FOR I=S1-1 TO S1+1
2610  FOR J=S2-1 TO S2+1
2620  IF I<1 OR I>8 OR J<1 OR J>8 THEN 2640
2630  IF Q[I,J]=4 THEN 2670
2640  NEXT J
2650  NEXT I
2660  GOTO 2730
2670  C$="DOCKED"
2680  E=3000
2690  P=15
2700  MAT D=ZER
2710  S=0
2720  GOTO 2810
2730  PRINT
2740  IF K3>0 THEN 2780
2750  IF E<300 THEN 2800
2760  C$="GREEN"
2770  GOTO 2810
2780  C$="*RED*"
2790  GOTO 2810
2800  C$="YELLOW"
2810  PRINT X$
2820  Z=0
2830  GOSUB 3330
2840  PRINT
2850  GOSUB 3330
2860  PRINT "STARDATE";SPA(5);T
2870  GOSUB 3330
2880  PRINT "CONDITION";SPA(5);C$
2890  GOSUB 3330
2900  PRINT "ENERGY";SPA(7);E
```

Figure 2: Command interpreter. A very simple interpreter is employed by the program. It requests a command input, tests the command for validity with a computed GO TO at line 780 to activate the appropriate command segment. Invalid commands fall through the GO TO statement and lead to printing of a command list on the output display.



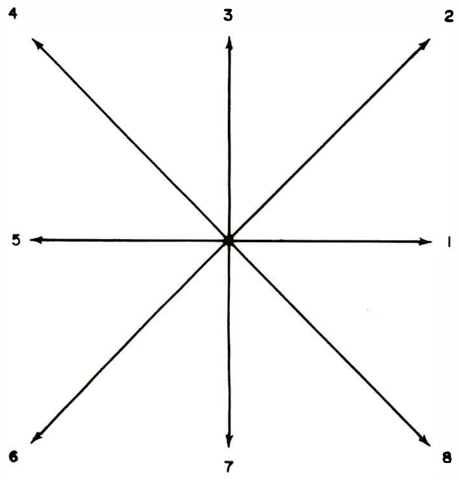
One warp factor represents the length of one quadrant. It is possible to move very short distances by using warp factor values less than one. Every time you move to a new location, you will get what is known as a short range scan which is a printout of the quadrant you are currently in. The symbols used in the short range scan are:

Enterprise <*>
star *
Klingon +++
starbase >!<

Figure 4 shows the actions which take place during the execution of this command.

Occasionally, after using enough warp factors to get you to who knows where, you will discover that you haven't gotten anywhere. This is because you have run into something, probably a star. Fortunately, your warp engines will always bring you to a screeching halt in time to prevent an accident. This is why it is a good idea to check your short range scan before laying out a

Figure 3: Course vector diagram. Numbers are used to determine the direction in which the Enterprise will move, or a photon torpedo is fired. These numbers are related to the points of a compass as shown here; fractional values are used to generate points in between these major headings.



course, to make sure you have a clear path to your destination.

Command 1 will output a long range scan. A long range scan is a table containing information on the quadrants bordering the one you are in. It is arranged on a 3 by 3 grid, with your own quadrant being the one in the center. You are given a three digit number for each quadrant. The hundreds digit of this number is the number of Klingon ships in that quadrant. The tens digit is the number of starbases, and the ones digit is the number of stars. Be sure to remember that leading zeroes will be suppressed on the printout. Sometimes an entire row on the long range scan will be made up of zeroes. This represents the edge of the galaxy, the perimeter of your range. The warp engines will not permit you to enter this area. Instead, you will bounce off the edge.

Command 2 is the phaser firing section. You may destroy a Klingon ship by firing enough units of phaser power to deplete his shields. The question is, how many units are necessary to do this? One factor you must consider is the amount of energy he has in his deflector shields. For every unit of energy you hit him with, his shields drop a corresponding amount. Your distance from the Klingon also matters since the amount of energy that reaches him lessens with distance. Your sensors will tell you how successful you have been in damaging the Klingons. Your phaser fire is evenly divided

Listing 1, continued:

```
2910  GOSUB 3330
2920  PRINT "TORPEDOES";SPA(4);P
2930  GOSUB 3330
2940  PRINT "SHIELDS";SPA(6);S
2950  GOSUB 3330
2960  PRINT "KLINGONS";SPA(5);K9
2970  GOSUB 3330
2980  PRINT
2990  PRINT X$
3000  RETURN
3010  PRINT "COMPUTER ACTIVE AND AWAITING COMMAND";
3020  INPUT A
3030  GOTO (A+1) OF 2280,3100,3310
3040  PRINT "FUNCTIONS AVAILABLE FROM COMPUTER"
3050  PRINT "    0=DAMAGE REPORT"
3060  PRINT "    1=PHOTON TORPEDO DATA"
3070  PRINT "    2=SHORT RANGE SCAN"
3080  PRINT
3090  GOTO 3010
3100  PRINT
3110  FOR I=1 TO 3
3120  IF K[I,3] <= 0 THEN 3200
3130  X=K[I,2]-S2
3140  Y=S1-K[I,1]
3150  IF X=0 THEN 3240
3160  A=INT(((57.3*ATN(Y/X))/45+1)*100)/100
3170  IF X>0 AND Y<0 THEN 3290
3180  IF X<0 THEN 3220
3190  PRINT "DIRECTION=";A
3200  NEXT I
3210  GOTO 700
3220  A=A+4
3230  GOTO 3190
3240  IF Y<0 THEN 3270
3250  A=3
3260  GOTO 3190
3270  A=7
3280  GOTO 3190
3290  A=A+8
3300  GOTO 3190
3310  GOSUB 2600
3320  GOTO 700
3330  REM ***** OUTPUT QUADRANT *****
3340  Z=Z+1
3350  FOR I=1 TO 8
3360  Z$="   <*>+++ * >!<"
3370  PRINT Z$[Q[Z,I]*3+1,Q[Z,I]*3+3];
3380  NEXT I
3390  IF Z=1 OR Z=8 THEN 3410
3400  PRINT SPA(5);
3410  RETURN
3420  REM ***** PRINTS DEVICE NAME *****
3430  RESTORE 3440
3440  DATA "WARP ENGINES","SCANNERS","PHASER BANKS","TORPEDO TUBES"
3450  DATA "SHIELD CTRL","COMPUTER"
3460  FOR X=1 TO R1
3470  READ Z$
3480  NEXT X
3490  RETURN
3500  REM **** PLACEMENT IN QUADRANT ARRAY ****
3510  R1=FNA(8)
3520  R2=FNA(8)
3530  IF Q[R1,R2]#0 THEN 3510
3540  RETURN
3550  PRINT LIN(1),"YOUR RESIGNATION HAS BEEN *ACCEPTED*"
3560  STOP
3570  PRINT "DO YOU NEED INSTRUCTIONS";
3580  INPUT A$
3590  PRINT LIN(5)
3600  IF A$[1,1]#"Y" THEN 440
3610  PRINT SPA(5);"<*> =ENTERPRISE"
3620  PRINT SPA(5);" *  =STAR"
3630  PRINT SPA(5);"+++ =KLINGON"
3640  PRINT SPA(5);">!< =STARBASE"
3650  PRINT LIN(2)
3660  PRINT "COMMAND 0=WARP ENGINES"
3670  PRINT "COURSE IS IN A CIRCULAR VECTOR AS SHOWN.";TAB(50);"4  3  2"
3680  PRINT "REAL VALUES MAY BE USED. FOR EXAMPLE,";TAB(51);"\ ^ /"
3690  PRINT "1.5 WOULD BE HALFWAY BETWEEN 1 AND 2.";TAB(52);"\^/"
3700  PRINT TAB(48);"5 ------- 1"
3710  PRINT "A 'WARP FACTOR' IS THE SIZE OF ONE QUADRANT.";TAB(52);"/^\"
3720  PRINT TAB(51);"/ ^ \"
3730  PRINT TAB(50);"6  7  8"
3740  PRINT "COMMAND 1=LONG RANGE SCAN"
3750  PRINT "CODED IN THE FORM XXX, WHERE THE UNITS ARE THE NUMBER"
3760  PRINT "OF STARS, TENS THE NUMBER OF STARBASES, AND HUNDREDS"
3770  PRINT "THE NUMBER OF KLINGONS."
3780  PRINT LIN(2),"COMMAND 2=PHASERS"
3790  PRINT "YOU MAY DESTROY THE KLINGON BY USING ENOUGH PHASER"
3800  PRINT "POWER AS TO DEPLETE HIS SHIELDS. KEEP IN MIND THAT WHEN"
3810  PRINT "YOU FIRE AT HIM, HE GONNA DO IT TO YOU, TOO!"
3820  PRINT LIN(2),"COMMAND 3=PHOTON TORPEDOES"
3830  PRINT "COURSE IS SAME AS WITH WARP ENGINES. THE LIBRARY"
3840  PRINT "COMPUTER CAN COMPUTE TRAJECTORY FOR YOU (OPTION 1)"
3850  PRINT LIN(2),"COMMAND 4=SHIELDS"
3860  PRINT "DEFINES THE AMOUNT OF ENERGY TO BE ASSIGNED TO SHIELDS."
3870  PRINT LIN(2),"COMMAND 5=LIBRARY COMPUTER"
3880  PRINT "    OPTION 0=DAMAGE REPORT"
3890  PRINT "  A STATE OF REPAIR LESS THAN ZERO INDICATES THAT"
3900  PRINT "  THAT DEVICE IS TEMPORARILY DISABLED."
3910  PRINT "    OPTION 1=PHOTON TORPEDO DATA"
3920  PRINT "  GIVES DIRECTION TO ALL KLINGONS IN YOUR QUADRANT."
3930  PRINT "    OPTION 2=SHORT RANGE SCAN"
3940  PRINT "  ALSO GIVEN AUTOMATICALLY AFTER SUCCESSFUL COMPLETION"
3950  PRINT "  OF WARP ENGINE MANEUVERS."
3960  PRINT LIN(2),"COMMAND 6=RESIGNATION"
3970  PRINT LIN(6)
3980  GOTO 440
3990  END
```

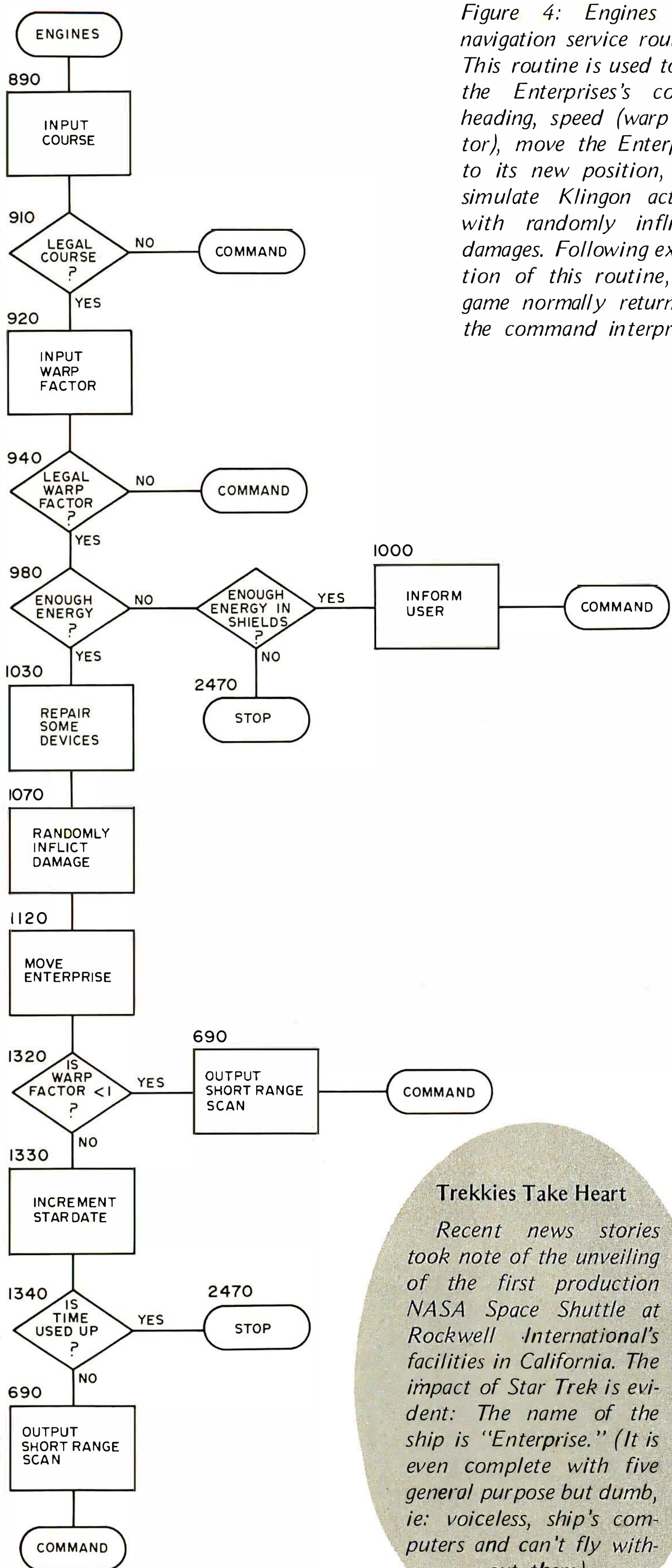
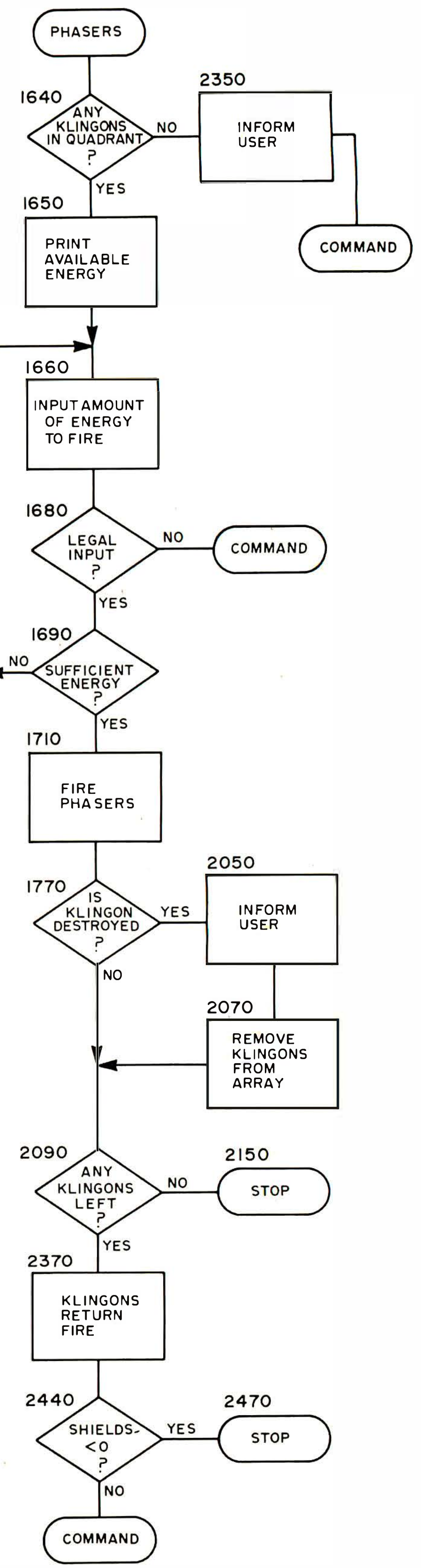


Figure 4: Engines and navigation service routine. This routine is used to set the Enterprises's course heading, speed (warp factor), move the Enterprise to its new position, and simulate Klingon actions with randomly inflicted damages. Following execution of this routine, the game normally returns to the command interpreter.

Figure 5: Phaser firing command service routine. The purpose of this routine is to fire the phaser, calculate damages to the Klingon ship (if any), and give the Klingon a chance to fire back with the effects of damage to the Enterprise computed.



Trekkies Take Heart

Recent news stories took note of the unveiling of the first production NASA Space Shuttle at Rockwell International's facilities in California. The impact of Star Trek is evident: The name of the ship is "Enterprise." (It is even complete with five general purpose but dumb, ie: voiceless, ship's computers and can't fly without them).

between all of the Klingons in your quadrant. Thus, if you fire 600 units, and there are two Klingon ships, you are in effect firing 300 units at each one. Figure 5 shows the flowchart for the phaser firing sequence.

Command 3 is for firing the photon torpedoes. To fire torpedoes, you must first know the direction to your target. This, like the navigation course, is determined on the circular vector shown in figure 3. The library computer can compute the torpedo trajectory for you.

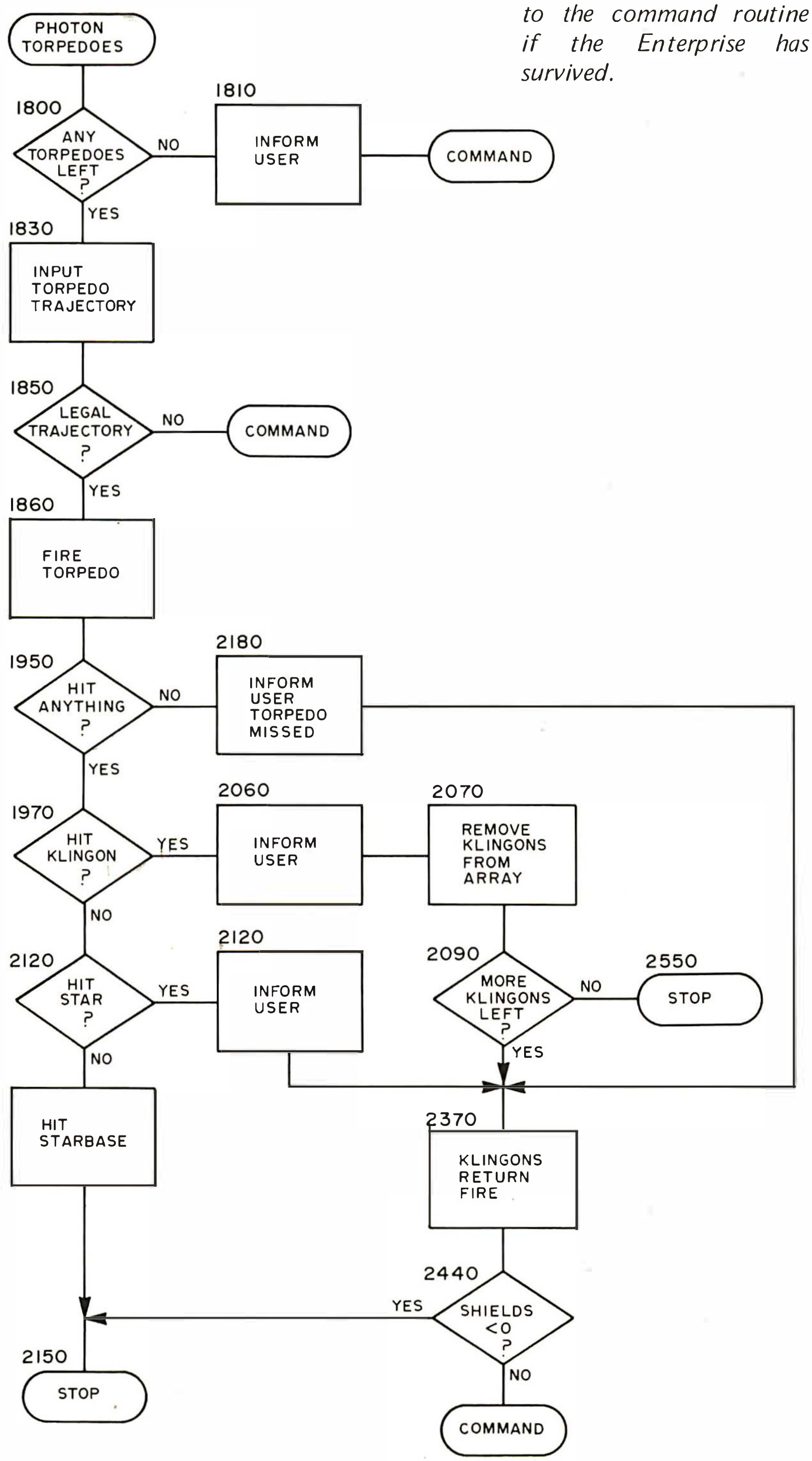
Often a star may be in your way, thus preventing you from hitting your would-be victim. The only way around this, other than using phasers, which do not follow a predetermined course and hence are not stopped by stars and other obstacles, is to use a small warp factor and maneuver in on the Klingon. Figure 6 shows the sequence that takes place when the photon torpedo command is initiated.

Command 4 allows you to raise or lower the Enterprise's deflector shields. It is neces-

Table 1: Some of the variables described by function. These variables have unique uses as described. Not all variables are listed in this table.

B3	=	The number of starbases in the current quadrant.
C$	=	String containing the current condition: red, green, yellow, or docked.
E	=	Amount of energy remaining.
K3	=	The number of Klingon battle cruisers in the current quadrant.
K9	=	The total number of Klingon ships in the galaxy.
N	=	Three digit number stating number of Klingons, starbases, and stars in quadrant.
P	=	The number of photon torpedoes remaining.
S	=	Units of energy currently assigned to shields.
S3	=	The number of stars in the current quadrant.
T	=	The current stardate.
TO	=	The stardate on which the game began.
Q1,Q2	=	Specifies the X and Y coordinates of the current quadrant within the galaxy.
S1,S2	=	Specifies the location of the Enterprise within the quadrant.
D(1)...D(6)	=	Each element contains the state of repair for its respective device, (ie: D(3) contains data for device No. 3).
G(1,1)...G(8,8)	=	Each element is a three digit number containing data on a single quadrant of the galaxy.
Q(1,1)...Q(8,8)	=	Each element is a number 0 to 4, specifying what type of object is situated in that sector of the current quadrant.
K(1,1)...K(3,3)	=	Contains information on the Klingons in the current quadrant:
K(I,1)	=	The X coordinate of Klingon number I.
K(I,2)	=	The Y coordinate of Klingon number I.
K(I,3)	=	The shield power of Klingon number I.
FNA(X)	=	Returns a random number in a form useful to the program.
FND(O)	=	Returns the distance from the Enterprise to another Klingon.

Figure 6: Photon torpedo command service routine. This routine is entered when a photon torpedo is to be fired. It calculates the trajectory, examines the results for any Klingon hits, allows for Klingon return fire, then returns to the command routine if the Enterprise has survived.



sary to be certain that your shields have sufficient energy before entering a combat area, because every time you fire at a Klingon, the Klingons fire back at you!

To clarify, you are subjected to Klingon phaser fire every time you use phasers or photon torpedoes. The amount of energy the Klingons hit you with depends on how far away they are. For every unit that reaches you, your deflector shields drop a corresponding amount. If they drop to less than zero, you lose the game. You are given a short message within the short range scan every time your shields get too low. You are also given a condition yellow whenever you get precariously low on energy. The sequence for raising the shield energy is given in the flowchart of figure 7.

Listing 2: Sample outputs of the program in listing 1.

```
GET-STTR

RUN
STTR

DO YOU NEED INSTRUCTIONS?N




COMBAT AREA     CONDITION RED
  SHIELDS DANGEROUSLY LOW

-----------------------
<*>       *
    *                        STARDATE     3000
                             CONDITION    *RED*
++        *                  ENERGY       3000
                             TORPEDOES    15
               *             SHIELDS      0
                             KLINGONS     26
      *     +++
-----------------------
COMMAND:?-1

0=SET COURSE          4  3  2
1=LONG RANGE SCAN      \ : /
2=PHASER CTRL           \:/
3=TORPEDO CTRL       5 ------- 1
4=SHIELDS               /:\
5=LIBRARY COMPUTER     /  :  \
6=RESIGNATION         6  7  8

COMMAND:?4
ENERGY AVAILABLE= 3000
NUMBER OF UNITS TO SHIELDS:?500

COMMAND:?5
COMPUTER ACTIVE AND AWAITING COMMAND?-1

FUNCTIONS AVAILABLE FROM COMPUTER

   0=DAMAGE REPORT
   1=PHOTON TORPEDO DATA
   2=SHORT RANGE SCAN

COMPUTER ACTIVE AND AWAITING COMMAND?1

DIRECTION= 7.9
DIRECTION= 7
COMMAND:?3
TORPEDO COURSE (1-9):?7

***KLINGON DESTROYED***
 22    UNIT HIT ON ENTERPRISE
COMMAND:?3
TORPEDO COURSE (1-9):?7.9

YOU CAN'T DESTROY STARS, SILLY!
TORPEDO MISSED
 22    UNIT HIT ON ENTERPRISE

COMMAND:?2
ENERGY AVAILABLE= 2500
NUMBER OF UNITS TO FIRE:?800
 86    UNIT HIT ON KLINGON

 13    UNIT HIT ON ENTERPRISE
COMMAND:?2
ENERGY AVAILABLE= 1700
NUMBER OF UNITS TO FIRE:?1000
 108   UNIT HIT ON KLINGON
 1     UNIT HIT ON ENTERPRISE
COMMAND:?2
ENERGY AVAILABLE= 700
NUMBER OF UNITS TO FIRE:?400
 43    UNIT HIT ON KLINGON
***KLINGON DESTROYED***
COMMAND:?1
-----------------
:   0 :   0 :   0 :
-----------------
:   0 :   5 :   1 :
-----------------
:   0 :   3 :   5 :
-----------------
COMMAND:?0
COURSE (1-9):?7
WARP FACTOR (0-8):?3
COMBAT AREA     CONDITION RED

-----------------------
<*>
```

```
++     *     *               STARDATE     3001
                             CONDITION    *RED*
                    *        ENERGY       281
                             TORPEDOES    13
       *                     SHIELDS      442
          +++   +++          KLINGONS     24
*
-----------------------
COMMAND:?5
COMPUTER ACTIVE AND AWAITING COMMAND?1

DIRECTION= 7.99
DIRECTION= 7.74
DIRECTION= 7
COMMAND:?3
TORPEDO COURSE (1-9):?7
***KLINGON DESTROYED***
 24    UNIT HIT ON ENTERPRISE
 28    UNIT HIT ON ENTERPRISE
COMMAND:?1
-----------------
:   0 :   2 :   5 :
-----------------
:   0 :205 :   5 :
-----------------
:   0 :   3 :202 :
-----------------
COMMAND:?0
COURSE (1-9):?0_1
WARP FACTOR (0-8):?3

-----------------------
<*>
                             STARDATE     3002
                             CONDITION    YELLOW
                 *           ENERGY       262
       *                     TORPEDOES    12
                   *         SHIELDS      [illegible]
                             KLINGONS     23

-----------------------
COMMAND:?1
-----------------
: 205 :   4 :103 :
-----------------
:   4 :   3 :   5 :
-----------------
:  13 :   1 :   4 :
-----------------
COMMAND:?0
COURSE (1-9):?6
WARP FACTOR (0-8):?1
-----------------------
<*>        *
  >!<                        STARDATE     3003
                             CONDITION    DOCKED
                             ENERGY       3000
                             TORPEDOES    15
           *                 SHIELDS      0
                             KLINGONS     23
                *
-----------------------
COMMAND:?0
COURSE (1-9):?3
WARP FACTOR (0-8):?2
COMBAT AREA     CONDITION RED
  SHIELDS DANGEROUSLY LOW

-----------------------
<*>    *        *
               +++           STARDATE     3004
                             CONDITION    *RED*
                             ENERGY       2989
        *                    TORPEDOES    15
                             SHIELDS      0
               *  +++        KLINGONS     23
               *
-----------------------
COMMAND:?2
ENERGY AVAILABLE= 2989
NUMBER OF UNITS TO FIRE:?1000
 82    UNIT HIT ON KLINGON
 54    UNIT HIT ON KLINGON

 20    UNIT HIT ON ENTERPRISE

    ***THE ENTERPRISE HAS BEEN DESTROYED***

THE FEDERATION WILL BE CONQUERED!!!

DONE
R
```

Command 5 allows the user access to the library computer which has three options specified by an integer between zero and two. If you enter an illegal option, such as a negative number, the computer will print a short list of commands.

Option 0 gives a damage report. The Enterprise may get damaged when you warp out at high speeds. When this occurs, you are informed as to which device has been affected. Extensive damage to a device may render it inoperable. In the damage report, each device is listed along with its respective state of repair. A state of repair less than zero indicates that the device is temporarily disabled.

Repairs are made, albeit slowly, by onboard technicians, but a faster way is to dock with a starbase. Not only does this automatically repair your ship, but you are also resupplied with energy and photon torpedoes. An extra bonus: While docked, you are protected from Klingon attack by the starbase's shields.

Option 1 calculates the torpedo trajectory to all Klingons in your quadrant.

Option 2 prints range scan. If you are docked with a starbase, it also replenishes your supplies.

Command 6 indicates that you wish to resign. Other good ways to end the game prematurely are to torpedo a starbase, or allow yourself to run out of energy.

Conversion Notes

As everybody knows, the growth of the personal computing field has been constantly hampered by the problem of standards. This has been particularly bothersome in the software agenda, where there are said to be no fewer than forty different versions of BASIC floating around. Consequently, I thought it would be appropriate to comment on some of the difficulties one might encounter in the conversion process.

Many BASICs have explicit matrix manipulation features. In particular I used MAT . . . ZER extensively. This statement initializes all the elements of a specified matrix to zero. It also allows the programmer to redimension the matrix.

LIN(X) appears in several places within the program. LIN is an output control function similar to TAB, which generates X number of linefeeds every time it is encountered.

GO TO. . . OF is replaced by ON . . . GO TO in many BASICs.

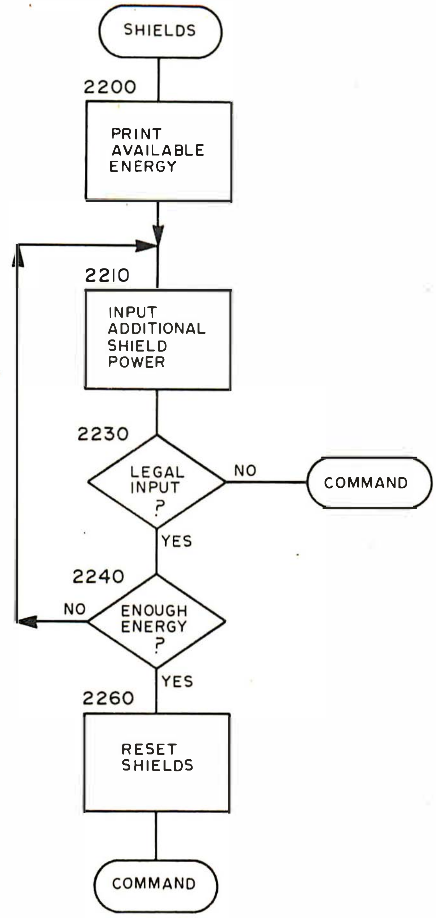


Figure 7: Shields service routine. This routine updates a power level for the Enterprises's shields.

Substrings in the form X$(1,x) are replaced by the construct LEFT$(X$,x) in Altair BASIC. Also, Altair BASIC does not require that strings be dimensioned.

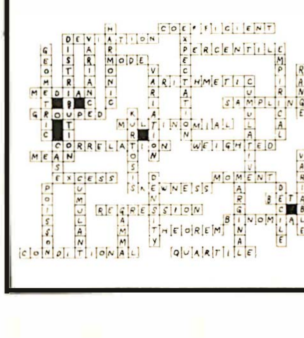
PRINT USING is used to format the long range scan. Output should appear in the following form: : xxx : yyy : zzz : The values of xxx, yyy, and zzz are the status reports concerning the number of Klingons, starbases and stars discussed under command 1.

The symbol # is used to express inequality within IF . . . THEN statements. Also, matrix subscripts are surrounded by brackets rather than parentheses. Near the beginning of the program, the sequence A=B=C=. . . is used to initialize many variables to the same value. This may produce unpredictable results on some machines.

The memory requirement of this particular version of Star Trek is 10 K bytes, plus interpreter. The program itself is 9382 bytes long. If your computer has an integer variables option, by all means use it. It can save you over 300 bytes on the matrices alone. If you are cramped you can also delete the instructions from the program. To do this, simply delete statement 350 and lines 3570 through 3980.■

Positively Baker Street

Here is the solution to the "Baker Street Irregular" which appeared on page 86 of the February 1977 BYTE.



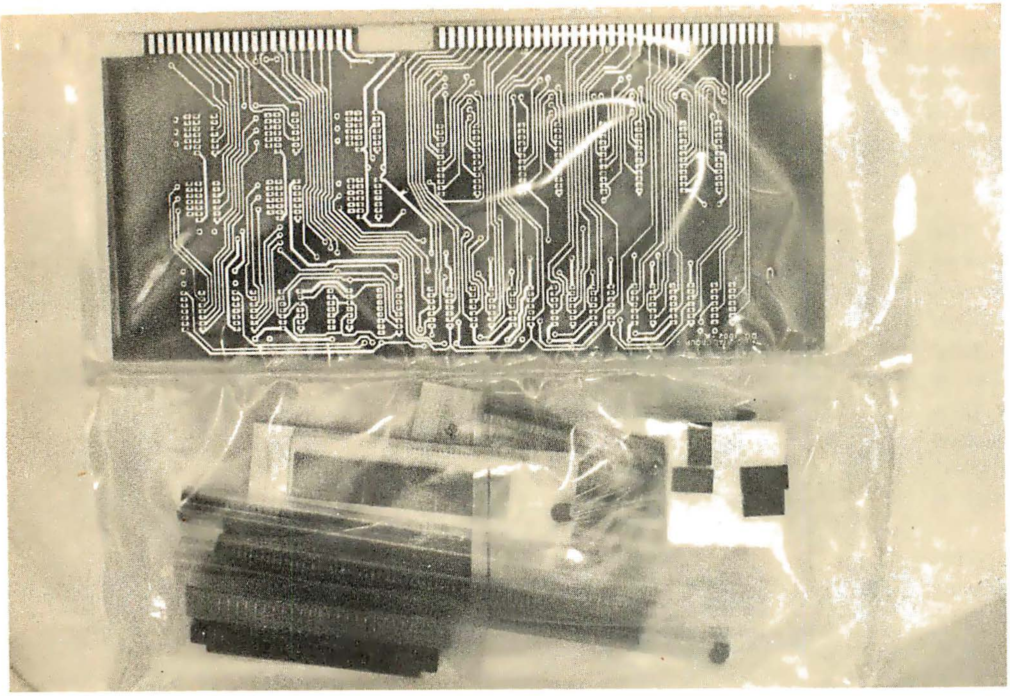


Photo 1: The typical board in a Digital Group kit comes in a sealed plastic bag with two compartments. One compartment contains the board and the second contains the necessary parts.

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Try This Computer on for Size

There are a number of fine microprocessor system kits available to the home computer enthusiast. One such system, which I just recently assembled, is the Digital Group 8080A. This microcomputer is marketed by the Digital Group in Denver CO. This concern, with Dr Robert Suding as its resident genius and designer, offers in my opinion the highest price performance of any home computer available. The Digital Group is somewhat unorthodox by not jumping on the bandwagon and being Altair bus compatible but their unit contains enough bells and whistles to placate even the most demanding computer owners.

This system, as is true of most others, has its good and bad points. I am an electrical engineer well versed in digital design and have been closely following the microcomputer scene since the advent of the MARK-8 in 1974. I have a Scelbi 8B and have helped friends build Altairs and IMSAIs from kits and feel that I can be completely objective. It is of course extremely difficult to restrain laudatory comments when one is so well satisfied, but bear with me.

The Digital Group sells a basic computer system which can contain one of four processor chips: the Zilog Z-80; AMD 8080A; MOSTEK 6800; or a MOS Technology 6502. I chose the 8080A because of a combination of price and software availability. The Digital Group System (DGS) is generally sold as a three board system with mother board. This three board microcomputer has the following functions and specifications.

- Processor Board
  - AMD 9080A
  - 2 K bytes programmable memory and EROM bootstrap loader.
  - Direct Memory Access (DMA) logic.
  - 8 level hardware vectored interrupt.
  - Buffered address and data bus lines.
  - 16 bit (64 K) addressing capability.
- Input Output Board
  - Four 8 bit parallel input ports.
  - Four 8 bit parallel latching output ports.
  - Full 16 bit port addressing.
- TV Readout and Cassette Interface Board
  - Video Readout:
    - Software controlled cursor.
    - 512 characters organized as 16 lines by 32 characters.
    - 7 by 9 character matrix.
    - Full 128 ASCII character set.
    - Upper and lower case alphabet.
    - Math symbols.
    - Special symbols.
    - Greek alphabet.

Direct video output.

Cassette Interface:

Uses standard cassette recorder.
FSK recording technique.
Wide shift Teletype frequencies.
Operates at 1100 bps.
Utilizes "software UART."

An additional 8 K programmable memory board is added to the three board set and is sold to make a four board set. The specs on the programmable memory are as follows:

8 K Static RAM Board

Uses 2102-1 parts with 500 ns access time.
No wait states.
Buffered address lines.
Address decoding covers full 64 K range.
Power consumption 2 A at 5 V.

There are many variations of the basic system as described, and this listing is only representative of their total offering. Interested parties should contact the Digital Group at POB 6528, Denver CO 80206.

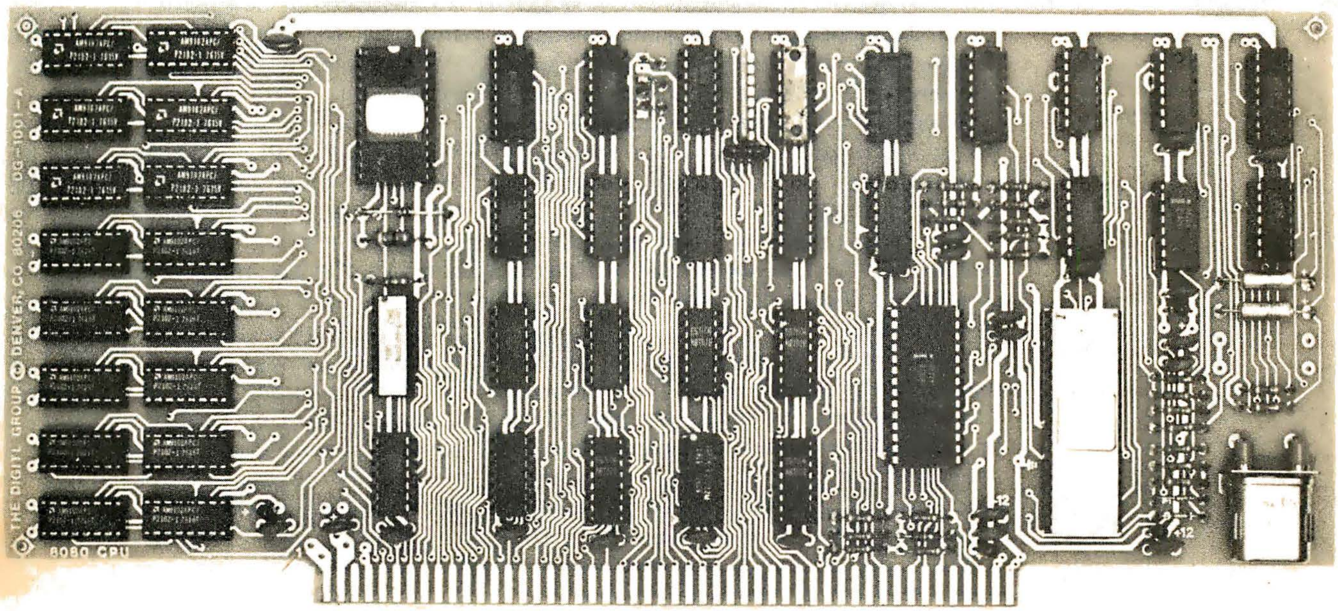
As I mentioned previously, I had been following the DG since they entered the microcomputer scene. Their first offering was a simple 300 bps "el cheapo" cassette interface which met absolutely nobody's standard. While everyone was arguing Kansas City and all the rest, I built this for $6 and had it operational in three hours. I have always been action oriented and all the talking in the world won't put your system on line. I have grown to expect and accept the unorthodox from the Digital Group.

Other manufacturers sell basic bare bones systems for prices starting around $600. For this price they contain a fancy case and front panel, gigantic overkill power supply, and a processor board with ancilliaries. There is no memory, IO, or mass storage capability: These are all extra cost options. Minimum capacity machine language and cassette storage system can approach $800 to $900. I affectionately refer to this nickel and diming as an "arm and a leg turnkey system."

The DGS is a profitmaking venture, I assure you; but it appears to have pricing and design philosophies which in my opinion better meet the needs and requirements of the knowledgeable experimenter.

When one buys a DGS three or four board system, you get Digital Group's version of the logically complete product: a system which in its basic price has no case, power supply or front panel. These are available from DG and can be purchased of course by the affluent or built from scratch by the frugal. Add a power supply, a video monitor salvaged from an old TV, a surplus

Photo 2: The author's Digital Group 8080 processor card. The actual processor is an AMD 9080A, one of the second sources of the original Intel 8080 design. The crystal which controls the processor clock is at the lower right, and the 2 K byte section of memory on the card is represented by the two rows of eight sockets at the left edge of the card. A UV erasable ROM chip (marked "80A" with a felt tip pen on the top edge at left of center) contains systems software which eliminates the need for a formal "blinkin' lights" front panel.



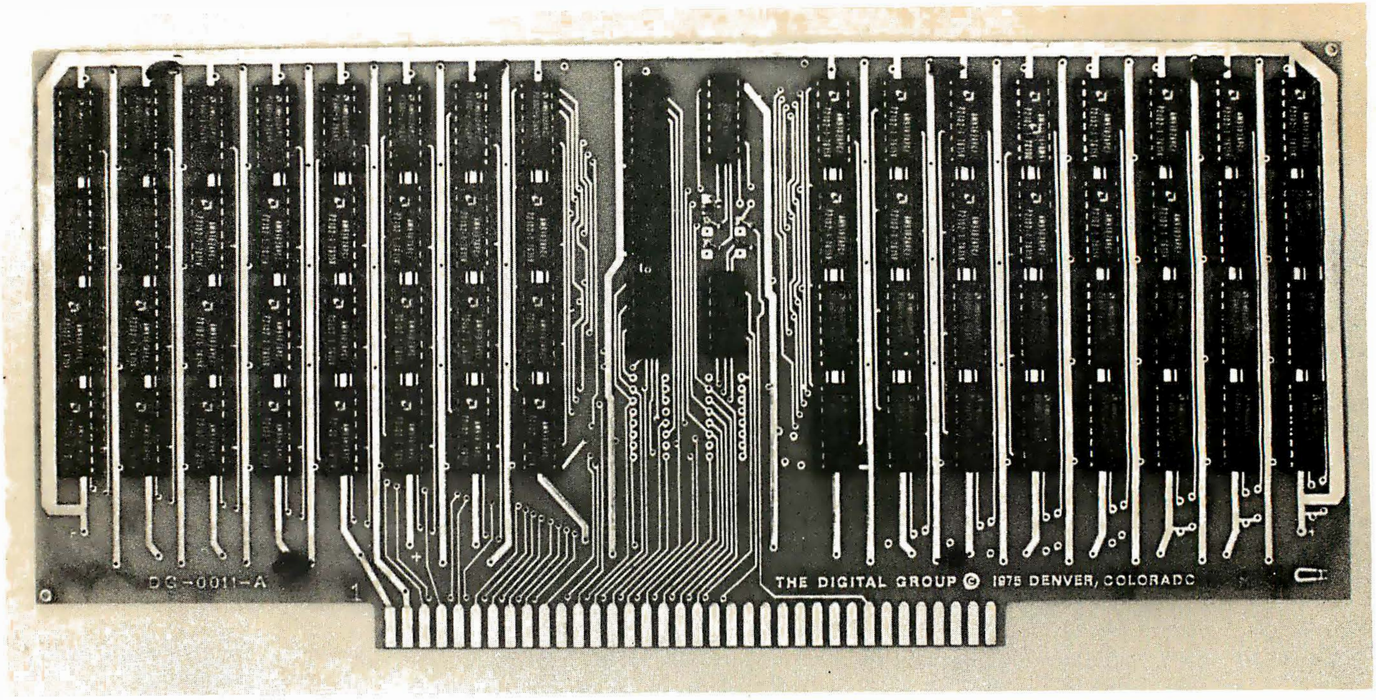


Photo 3: The author's Digital Group System 8 K byte memory card. The card contains 64 memory integrated circuits (in two arrayed segments) and in the center are various miscellaneous circuits used to interface the backplane bus of Digital Group system.

ASCII keyboard, and a decent cassette recorder; and you are in business with a complete functioning microcomputer.

I had been hearing this rhetoric and receiving DGS flyers for a while. Then I decided to take the plunge. I called DGS one morning in mid 1976 and ordered the four board 8080A system with standard mother board. Since this four board set contains 10 K bytes of programmable memory and is capable of supporting an Extended Tiny BASIC, I ordered the TBX software for $5. The total 10 K system as ordered was $645. Literature supplied by DGS quoted 30 day delivery but I had resigned myself to the possible two month wait that friends were experiencing with other companies. When the complete package arrived three weeks later I was ecstatic and set out immediately to the task of getting "on line."

The packing material, though sparse, was adequate; and, since there were no heavy components like transformers, its lack was inconsequential. Like any kit builder, I expected the first project would be to separate the pile of parts and boards and to sort components out among the respective boards. Anyone who has ever experienced sifting through a pile of resistors until their eyes cross can appreciate what I am saying. Fortunately this was unnecessary. Each board is packaged in a two compartment sealed plastic bag. One side contains the blank printed circuit board and the other contains all the integrated circuits, sockets, and other components as seen in photo 1. When unpacking, two things are immediately apparent. The boards are top quality with plated through holes and there are no jumpers.

I searched through the box looking for the usual last minute revision sheets and tackons but there were none. This apparently was a final design with absolutely no "kluge rigging" necessary to make it work. The Digital Group flyers indicate they do not sell interim designs nor advertise anything for sale until it is available "off the shelf." From my experience, this appears to be the truth.

The ease of construction of this system is a function of the particular board being assembled. I'll cover each board separately, but a word of caution first. The Digital Group System is not and should not be considered in the same realm as a Heathkit or similar undertaking. Hardware documentation is adequate and descriptive but is not as detailed pictorially as a Heathkit. This is not a kit but rather an unassembled microcomputer. Its construction should be attempted by the experienced kit builder only. If necessary, build several difficult Heathkits first to gain experience with electronics components and assembly. At the least, difficult assemblies should be purchased as fully assembled and tested units and the other cards carefully constructed.

Building the Processor Board

The processor board is of course the heart of the microcomputer. This card contains the microprocessor itself and supporting components. It is shown (after I assembled it) in photo 2. The Digital Group has sought to learn from the experiences of other manufacturers and builders and has obviously benefited. The most notable addition is the incorporation of integrated circuit sockets throughout. Even with the use of prime components, bad circuits are possible. The average hobbyist may have considerable experience doing the initial soldering, but unsoldering an integrated circuit is quite messy. Using sockets adds the capability of quickly changing a suspected bad component without either destroying the integrated circuit or the printed circuit board.

Significant effort and thought has been put into this microcomputer design as is evident in the system architecture of the processor card. The microprocessor is driven by a crystal controlled clock which exhibits none of the frequency instability of multivibrator controlled clocks. Crystals are currently used in most microprocessor systems for their "rock like" stability. In addition, there is 2 K of programmable memory on the board which can be selected to respond to any two consecutive 1 K positions in memory address spaces. For startup and checkout, this memory should be set for 0 to 2 K allowing the user to perform limited machine language programming without additional memory. I'll cover the procedure for checkout a bit later.

There are of course other goodies on this card. Direct Memory Access (DMA) and priority interrupt hardware is provided as a user option. The basic three and four board systems include test procedures for the interrupt request logic but DMA checkout is left for the brave of heart and is not addressed here. In addition to this circuitry, a 1702A EROM containing the tape cassette bootstrap loader is located in Page 0 of memory. When power is turned on, a power on reset signal initializes the system and reads in the operating system cassette. More on this later.

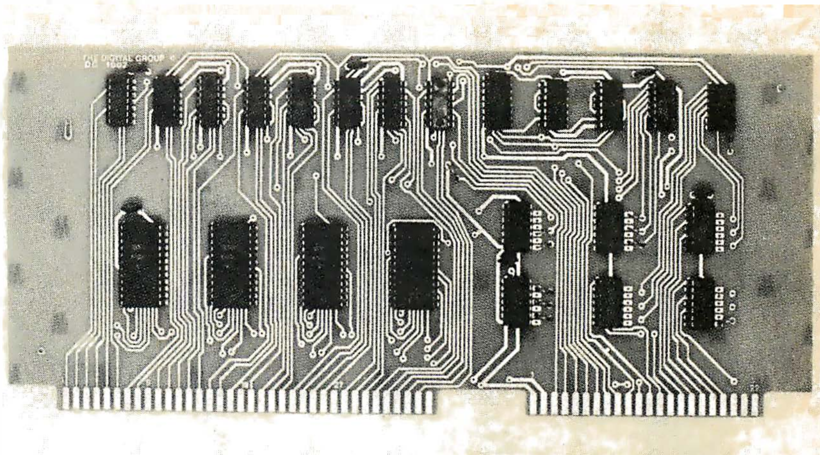


Photo 4: The author's Digital Group System IO card. This card interfaces to the system's bus, providing four parallel output ports and four input ports. These ports are routed to the backplane where they communicate to the video display, keyboard and cassette interfaces.

The Digital Group System bus structure is similar but differs in detail from that of the Altair. Robert Suding's publicized philosophy dictates an interchangeable processor capability which hopefully decreases the obsolescence of the total system. As new and more powerful microprocessors such as the Z-80 come on the market, a new processor card should be interchanged with the bus of the older unit while not affecting the rest of the system. To accomplish this goal, the Digital Group system uses unidirectional address and data buses as in the

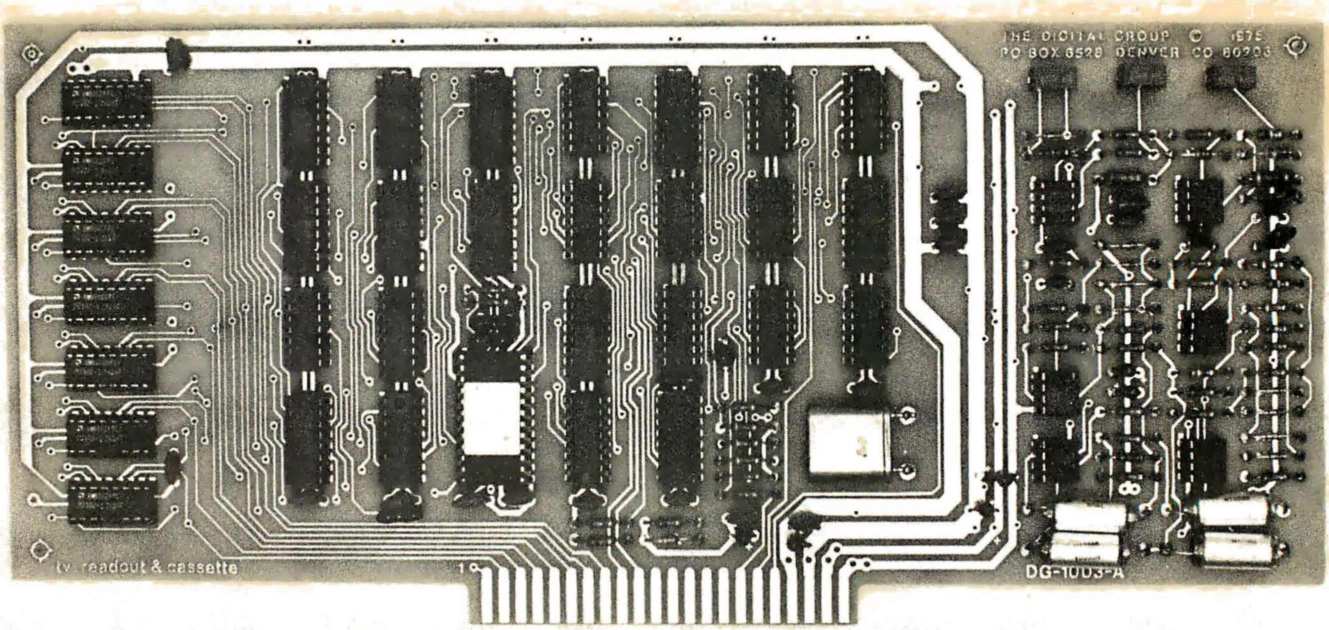


Photo 5: The cassette and CRT interface board. This board contains the video signal generation and audio processing circuits of the Digital Group System. [For more detailed descriptions, see the July and August 1976 issues of BYTE.]

Altair. Such a bus structure, as has often been seen in the marketplace, is easily adapted to any 8 bit processor. There is of course a basic disadvantage to owning a unique backplane pinout, that of having only a single source. Every microprocessor manufacturer knows that few designers will tie themselves to a single source part. That is the reason you see so many different companies producing 8080s. The Altair bus has been widely second sourced, which has led to some fierce competition resulting in modest benefits to the buyer. Obviously the small system owner does not have the same constraints as the high volume manufacturer but he should be aware of the lack of price competition and interchangeability when it comes to memory and IO card expansion. The Digital Group is apparently aware of their unique position and has sought to dispell concern by selling blank IO and 8 K memory boards at a very reasonable price. This allows the user to shop around for the best 2102-1 memory prices.

Since the DGS has no front panel, the processor card cannot be checked out easily by itself. But then no real functional test of a processor system as a whole can be easily performed with a front panel, either. The rest of the system must be constructed to perform the necessary diagnostics.

Assembling the Memory and IO Boards

Both the 8 K memory and parallel IO boards are constructed in a very straightforward manner. Again all integrated circuits are socketed and literature supplied is both explicit and clear. The memory board (see photo 3) and components supplied to me contained premium grade AMD 2102-1 parts. With these parts no wait states are required and the processor runs at full rated speed.

The IO card which contains four parallel inputs and four latched parallel outputs must be set to the lowest order addresses when only one IO board is in the system. This is because the video display generator, keyboard and cassette interface are directly wired to IO ports on this card through the mother board. The ports are address selectable; but to utilize the DGS operating system software, the addresses must be set as described in the DGS write up. Additional memories or IO can have addresses to suit the user.

Assembling the Cassette and CRT Interface Board

This board is the external communications medium of the Digital Group microcomputer. Since the DGS has no front panel, it is solely dependent upon a video based operating system utilizing the video display generator interface and a television monitor, or modified television. The software for such an operating system is about 1.5 K and cannot be entered except through the cassette interface. I should clarify one thing though. The DGS which I purchased is quite amenable to front panel hookup. The three and four board units sold by the Digital Group do not incorporate front panels but they do provide a design for one. Obviously,

if a user builds a DG system and both his processor and video display sections fail to function properly, he is dead in the water and would have to build the front panel. The design is neat and functional and plugs into any spare memory card slot. If, on the other hand, the user is thoroughly frustrated, suspect boards can be returned to DG for troubleshooting according to a price schedule supplied with the unit.

Now that you know how to get yourself out of the hole if it happens, I'll explain the proper method of digging.

The CRT and cassette interface sections are assembled using the same methodical approach as the other boards. The literature is very good in this respect. The problems come in calibration. The CRT is fairly straightforward, it either works or it doesn't. There are no adjustments. This section, when completed, is plugged into the mother board, attached to a monitor, jumpered as per the testing procedure, and powered up. If it works the screen will be immediately filled with 512 random characters. These characters include upper and lower case alpha symbols, and Greek lettering. When this works you are half done with the check out of the card.

Being half done in this case is not nearly enough. The assembly of the cassette interface is simply a matter of following directions but calibrating it is a bit of a task. There are operating system options which allow the computer to function as a frequency counter, but that is a little further downstream. To properly adjust the cassette interface, a scope, a frequency counter, an accurate DC voltmeter or DVM and a variable frequency oscillator are required. I fortunately have all this equipment, but not everyone's spouse is as understanding as mine. The frequency source is set to 1 V p to p at 2125 Hz and applied to the interface input, simulating the tape recorder output. Using a scope to determine the point of peak response, the active filters are adjusted correspondingly. This procedure is repeated for 2975 Hz. Next the comparator which detects whether the input frequency is at a mark or zero is adjusted to switch cleanly as the frequency source sweeps between the two valves. That takes care of the receiver sections.

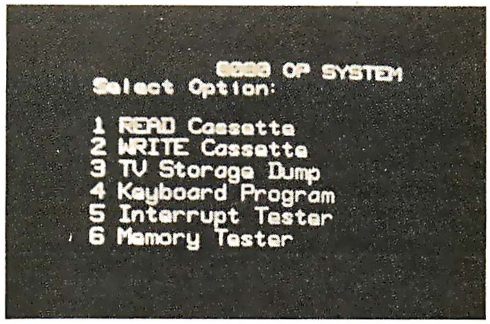


Photo 6: When you get this far, you know your Digital Group System has arrived in the land of the living.

The FSK (frequency shift keyed) modulator is a single VCO (voltage controlled oscillator) chip which switches between two frequency values corresponding to TTL one or zero inputs. In initial checkout, a voltage (3.5 V) simulating a TTL level one is applied to the control line of the oscillator and the output is adjusted to 2125 Hz. The control line is then grounded and the output adjusted to 2975 Hz. If this can be accomplished satisfactorily, you're in business.

System Checkout

When all of the cards are assembled, and the solder splashes cleaned off, take one last look at each card. Remember, this is the smoke test.

Attach the power supply to the mother board and with no boards inserted and the power on, check that the proper voltages are present. Shut off the supply and insert the

processor, IO and CRT cards. Cross your fingers and turn on the power. If all works correctly, the screen will display: "READ 8080 INITIALIZE CASSETTE". Successfully accomplishing this means that the processor is operating correctly, the CRT board works fine and at least part of the IO board is functioning.

The acid test is loading the operating system via the cassette interface. (To facilitate this endeavor and add more ease of operation, a Reset/Run button should be wired to the mother board as described in the DG literature.) With this message present on the screen, insert the 8080 operating system cassette and hit the play button. Adjust the output level to be about 1 V p to p and soon a leader tone should be heard. No change should appear on the screen. Immediately following the tone will be the asynchronous data at 1100 bps. Proper reception of this data will be evident on the video display. As each byte of data is processed and loaded into memory, it is read from memory to verify that it got there. If it loaded correctly, a number corresponding to the high order digit of the octal page address of this byte location is printed on the screen. With 256 bytes per page, there will be 256 number 1s, 256 number 2s, etc, until the tape is loaded. Should the memory check signify a bad byte, a period (".") will be displayed instead of the octal number. It's a good idea to watch the screen while the cassette is being read.

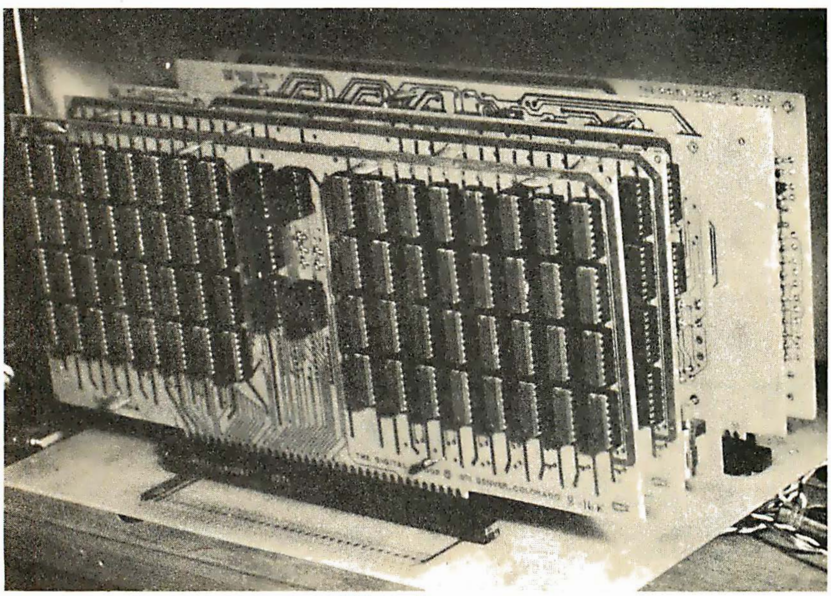


Photo 7: A view of Steve's assembled Digital Group System. [When a party from the BYTE office stopped by at Steve's basement laboratory in Connecticut on the way back from Atlantic City last fall, we found his system up and running as pictured here, with his older Scelbi 8B computer acting as a slave peripheral processor to control the vector graphics output device described on page 78 of the November 1976 BYTE. Steve cooked an excellent Quiche Lorraine for dinner that night while Dan Fylstra and I explored a game of KINGDOM running in Tiny BASIC . . . CH]

If the cassette was read in properly, the computer will display the operating system options on the screen as in photo 6. If not, try again. Be careful to watch that there are no numbers, signifying received data bytes, on the screen prior to the playback of the actual data on the tape. Should this occur due to a noise glitch, hit the reset, and it will clear this problem.

The DGS operating system requires that alphanumeric information be input on a parallel 8 bit input port in the form of ASCII. All this means is that you need a keyboard. The ASCII is 7 bits of the input port and the eighth bit corresponds to the key pressed or strobe signal. The operating system scans this bit looking for a transition from a zero to a one so therefore it must be a positive going strobe (TTL level) with a minimum duration of 50 µs. I have a surplus Sanders Associates 720 keyboard which a lot of people have. This keyboard has a 5 µs negative going strobe though and must be modified by adding a oneshot such as a 74121 to it. Since the whole keyboard runs on 5 V, this is an easy conversion and the keyboard is an exceptional buy. With keyboard and monitor, the system is totally operational. If you were able to get the operating system option list which appears in photo 6, you are ready to go. Hit 3 and the screen displays the contents of all the registers and flags. Hit space and you'll start to page through memory displaying all memory contents. Return to the operating system and hit option 4 and the keyboard can be used to enter octal machine language code anywhere the user desires. The complete explanation is included with operating system tape.

Where the Digital Group System really shines is the cheap software and system simplicity. Add the 8 K memory board, set the address for 0 to 8 K and reset the processor 2 K memory to occupy 8 K to 10 K and we are ready to run Extended Tiny BASIC.

With 10 K of memory installed, turn the system on and start the 10 K Tiny BASIC tape as you would the operating system tape. After a few minutes the tape will have been read and the system will display the Tiny BASIC options:

TINY BASIC

1. READ BASIC PROGRAM
2. WRITE BASIC PROGRAM
3. DISPLAY COMMANDS

4. DISPLAY ERROR CODES
5. CONTINUE PROGRAMMING
6. TINY BASIC

With these options, an Extended Tiny BASIC, created by Dick Whipple and John Arnold and described in the January 1976 issue of *Dr Dobb's Journal of Computer Calisthenics and Orthodontia,* is ready to go. Buy a couple of simple programs such as Blackjack, Bantum and others from the Digital Group Software Systems, and you can utilize the computer immediately to entertain the whole family or bone up on Tiny BASIC and write your own programs.

Observations and Criticisms

As stated earlier, it is my opinion that the Digital Group System is one of the best offerings on the small systems market today. But as previously mentioned, anyone not having the proper equipment should not attempt to assemble the CRT and audio cassette interface. After receiving my system, I was up and running with the 2 K processor card memory with two evenings' work. Since I had the equipment and am very receptive to logical well written instructions, I had no troubles. My cassette interface didn't work at first, and I discovered that it was because of insufficient tape recorder bandpass. I had hoped to use the same el cheapo recorder that I used for my previous 300 bps interface, but no way. I rushed out and spent a whopping $39 for a new one from J C Penney which had been suggested by another Digital Group System owner. The first time I hit play, it worked perfectly. Since that time, I have discovered that the cassette interface is sensitive to both volume and tone settings during playback. This is probably only a function of the tape recorder I own and is not necessarily indicative of a general problem. Using a quality cassette recorder of the type suggested by the Digital Group should eliminate any playback problems.

Recording a program on tape is simply a matter of choosing the correct operating system option but getting accurate mark and zero frequencies may require minor tweeking. There appears to be some shift in the output frequencies from the time of the static calibration and actual dynamic operation. This is obviously due to the fact that 3.5 VDC and 0 V are not the actual TTL levels applied to the voltage controlled oscillator. A VCO is an analog device and not all TTL chips are exactly alike. After reading in the operating system tape I

Continued on page 129

Multiplex Your Digital LED Displays

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Digital LED displays were once a novelty to the hobbyist, a luxury found in expensive lab equipment. They are now a household word and a useful tool for the digital experimenter. A digital LED display can be used as the readout for almost any test instrument. A programmable LED display can be used as a computer output. A digital LED display is a handy replacement for the binary lights on a computer control panel. If you have been thinking about using an LED display for any of these or other reasons, this article may save you some time, money, and power.

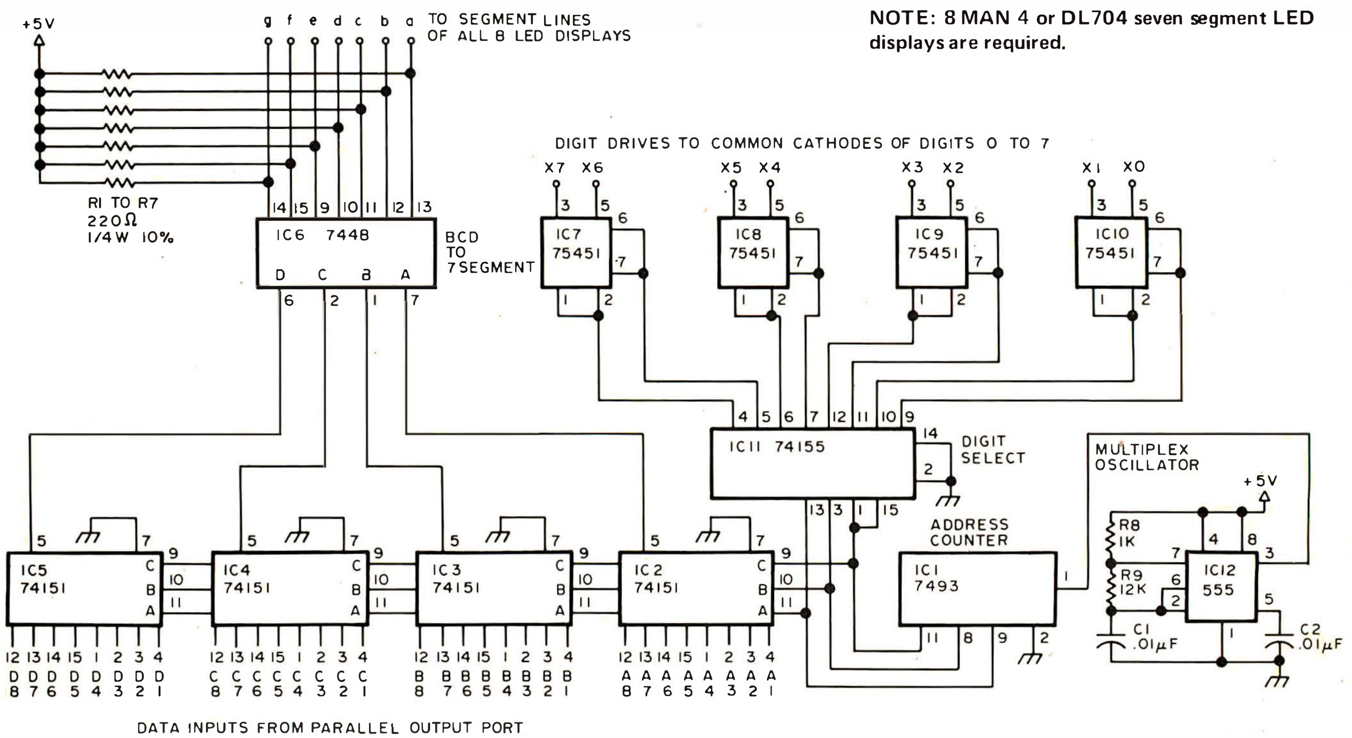
There are two methods which may be used to drive an LED display. The direct

Figure 1: Circuit diagram of a simple multiplexed 8 digit display for BCD or octal data. The printed circuit layout of this version is depicted in figure 3. Figure 5 shows the printed circuit used to mount the displays.

Integrated Circuit Summary List

	Type	POWER +5 V	PINS GND
IC1	7493	5	10
IC2	74151	16	8
IC3	74151	16	8
IC4	74151	16	8
IC5	74151	16	8
IC6	7448	16	8
IC7	75451	8	4
IC8	75451	8	4
IC9	75451	8	4
IC10	75451	8	4
IC11	74155	16	8
IC12	555	See figure 1	

NOTE: 8 MAN 4 or DL704 seven segment LED displays are required.



power configuration uses one 7 segment driver for each 7 segment LED in the display. Constant power is supplied to all digits. The multiplexed configuration uses only one 7 segment driver for several digits. Power is supplied to only one digit at a time, but is switched at a high rate so all digits appear to be on constantly. Since only one digit is powered at any given time, a certain amount of power is saved. This principle is widely used in electronic calculators.

The circuit of figure 1 is the driver circuit for an 8 digit multiplexed LED display. This circuit will display 8 digits of parallel BCD data. All data inputs are connected to a multiplexer. There is one 8 channel multiplexer for each of the 4 data input bits. The least significant bit of each digit is connected to an input of IC2; the most significant bit of each digit is connected to an input of IC5, etc. The multiplexers and demultiplexer are addressed by the 7493 counter which is incremented at approximately 4 kHz by the 555 oscillator. IC11 is connected for 3 to 8 line demultiplexing. When the selected output line of the demultiplexer goes to a low state, one of the peripheral interface gates is enabled. IC7 through IC10 are dual peri-

Integrated Circuit Summary List

	Type	POWER +5 V	PINS GND
IC1	555	See figure 2	
IC2	74123	16	8
IC3	74193	16	8
IC4	7489	16	8
IC5	7404	14	7
IC6	7448	16	8
IC7	75451	8	4
IC8	75451	8	4
IC9	75451	8	4
IC10	75451	8	4
IC11	75451	8	4
IC12	75451	8	4
IC13	75451	8	4
IC14	75451	8	4
IC15	74154	24	12

NOTE: 16 MAN 4 or DL704 seven segment LED displays are required.

Figure 2: Circuit diagram of a digit-serial multiplexed 16 digit display with memory. The printed circuit layout of this version is depicted in figure 4. Figure 5 shows the printed circuit (two copies required) used to mount the displays.

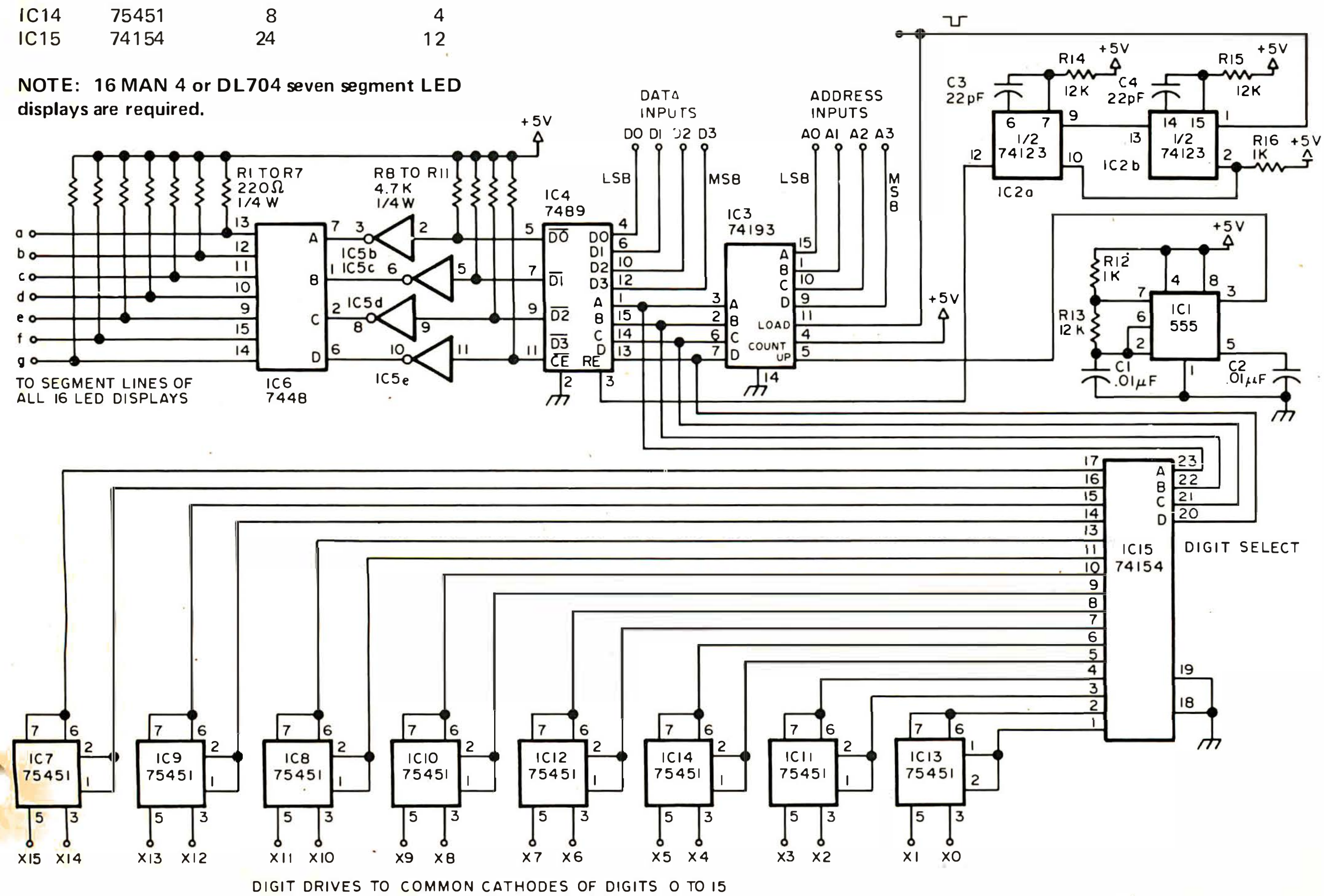
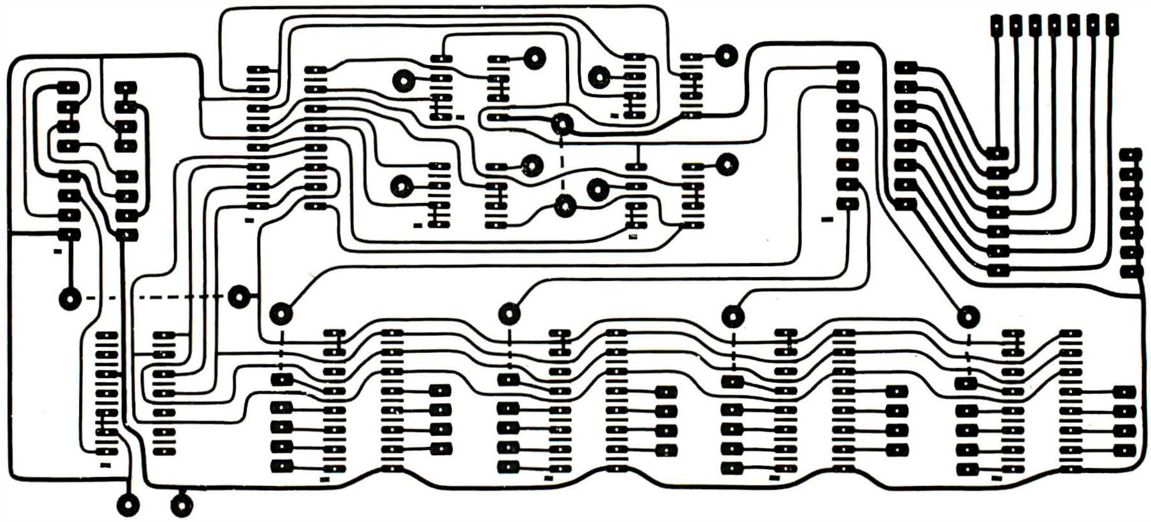


Figure 3a: Printed circuit pattern (foil side) of the 8 digit display circuit.



pheral interface gates. Each gate is capable of sinking a current of up to 300 mA. When a digit is selected, the interface gate provides a ground path for the common cathode of the 7 segment LED. Only the LED whose cathode is grounded will light up. Although the same data will be present at all digits, the data will be displayed by only one digit. By changing the data present and switching the enabled digit, each digit will display its own data. A 7448 decoder/driver converts the BCD data to a 7 segment code and drives the individual segments of the LEDs. The segments of all 8 digits in the display are connected in parallel.

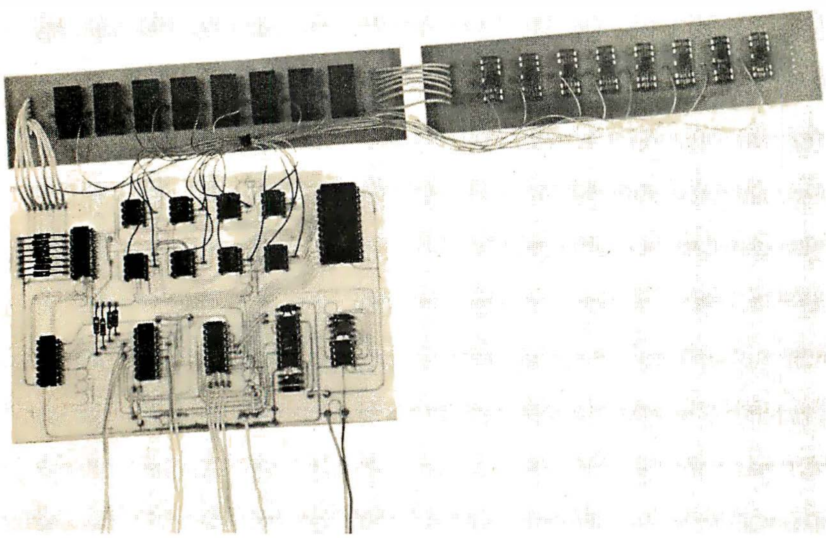
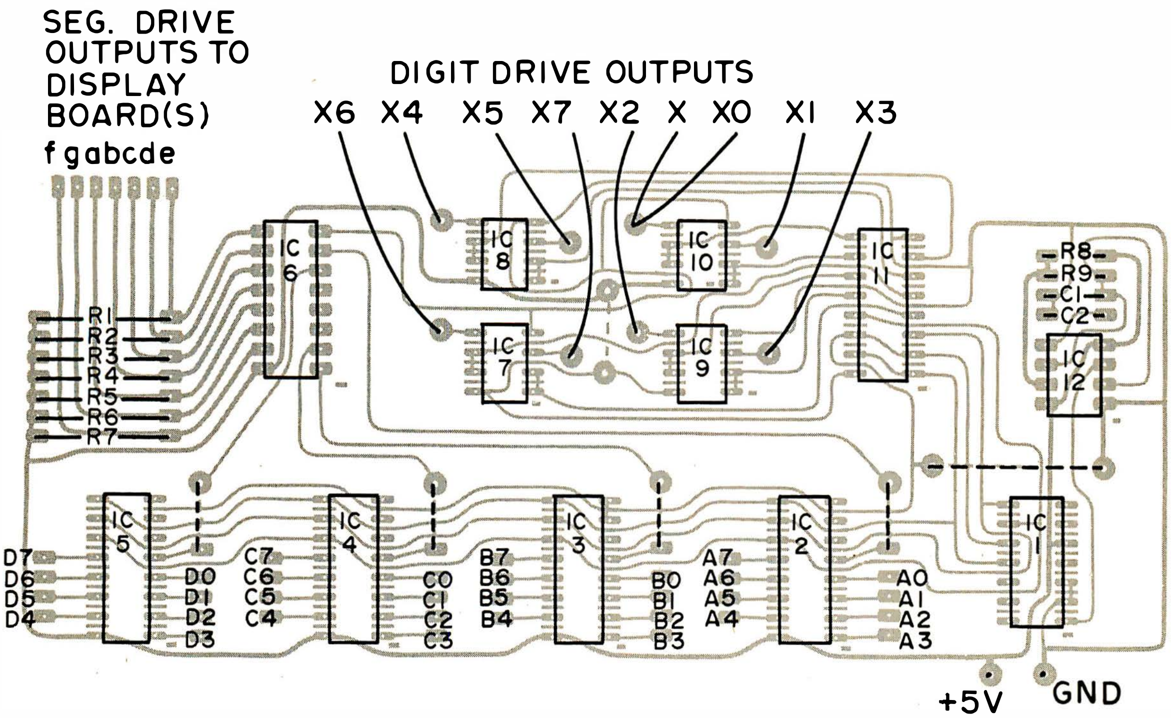


Photo 1: A 16 digit BCD assembly constructed using the circuit of figure 2, with the printed circuit layouts of figures 3 and 5. The 16 digit memory display requires two copies of the LED mounting board, with jumpers connecting the segment lines from one board to the next. Power, data and address inputs are shown trailing away at the bottom.

The circuit of figure 2 is a 16 digit programmable display. This circuit will memorize and display the data presented at its inputs one digit at a time. The size of the demultiplexer and the number of peripheral interface gates is doubled, since the programmable display has 16 digits. The input multiplexer is replaced by a memory which is loaded digit by digit. The 7489 TTL RAM, IC4, is very conveniently arranged for a 16 digit BCD memory. The RAM outputs are, however, inverted open collector outputs, so pullup resistors and inverters (IC5b to IC5e) are needed.

The counter used is a 74193 presettable binary counter, IC3. A 555 oscillator (IC1) drives the counter at 4 kHz. A digit is selected for programming by setting the memory address at the inputs of the counter. An external clock pulse at the clock input will program that digit. It is assumed the external clock pulse will be at least 200 ns. When the clock pulse input line goes low,

Figure 3b: Printed circuit component side map of the 8 digit display. See figure 1 for identification of components. Jumper wires are shown as dotted lines in the overlay.

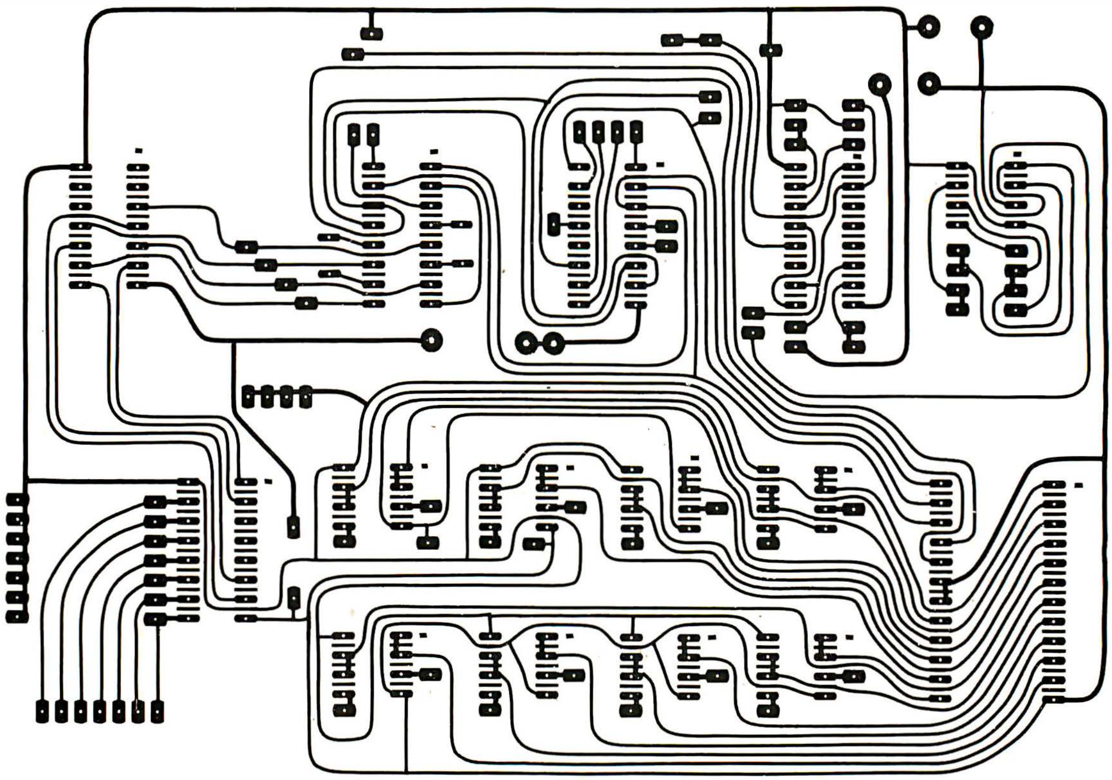


the counter will be disabled and the address on the counter inputs will appear at the outputs addressing the memory. IC2 provides a 60 ns delay, then a 60 ns pulse which writes the data at the memory data inputs into the memory location addressed. When the clock line returns to the high state, the counter will resume counting. The counter sequentially addresses the BCD data stored in the memory while it selects and enables the appropriate digit in the display.

Single layer printed circuit patterns are provided for readers who make their own boards. The inputs on the simple multiplexed driver board (figure 1 schematic, figure 3 printed circuit layout) are connected as follows: Bit 0 of the first digit to input A0, bit 1 to input B0, bit 2 to input C0, bit 3 to input D0, bit 0 of the second digit to input A1, bit 1 to input B1, etc. The segment outputs (a to g) should be connected to the display board (see figure 5b) at the pads provided on either end of the board. The digit (common cathode) driver outputs (X0 to X7) should be connected to pin 4 of their respective digits.

Output connections for the 16 digit programmable display driver board (figure 2 schematic, figure 4 printed circuit layout) are the same as for the self scanning board. Referring to the component placement diagram, connect the BCD data input directly to the D_0, D_1, D_2, and D_3 lines of IC4. The

Figure 4a: Printed circuit pattern (foil side) of the 16 digit memory display circuit.

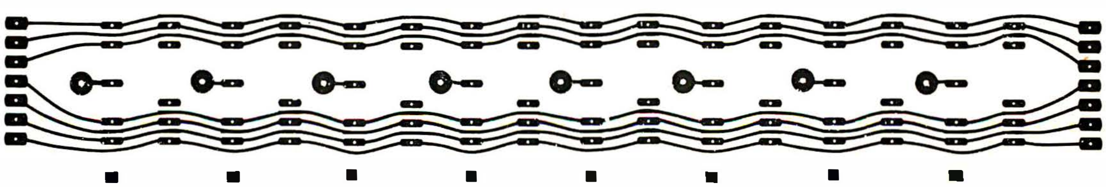


digit address input lines are connected to IC3 inputs A, B, C and D. To program the display, set the desired BCD value at the BCD inputs, select the desired digit with address lines A0 to A3, and bring the clock input to the low state for a minimum of 200 ns. The first digit is selected by setting a binary 0 at the address input; digit number 4 is selected by setting a binary 3 at the address input, etc.

Any 7 segment common cathode LED may be used with this display. MAN 4 or DL 704 LEDs work well, wired up using the display card of figure 5. The use of the peripheral interface gates means that a single 5 volt power supply will be adequate without any extra LED driver circuitry. The entire display (either one) will draw 300 to 400 mA.

The 8 digit multiplexed display may

Figure 5a: Printed circuit pattern (foil side) of an 8 digit 7 segment LED assembly used with the display circuits.



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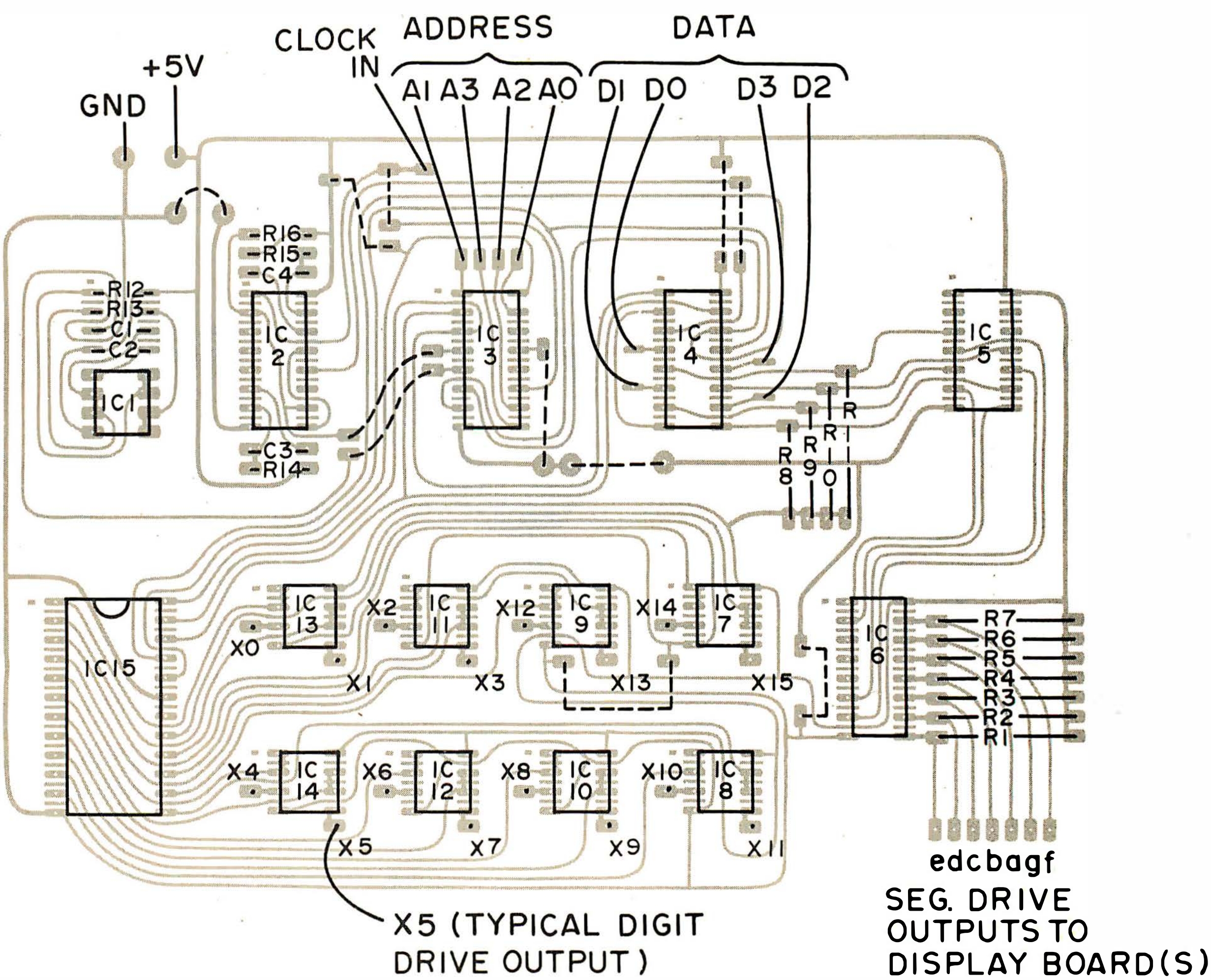
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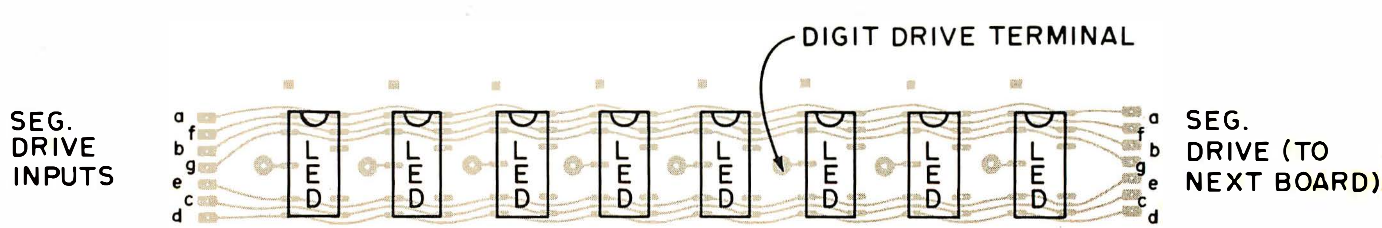
Figure 4b: Printed circuit component side map of the 16 digit display. See figure 2 for identification of components. Jumper wires are shown as dotted lines in the overlay.



easily be used to replace the binary lights on a computer as an octal display. This display board is also a handy readout for any number of homebrewed instruments.

The programmable display may be used as a computer output. Connect the address and data inputs of the board to the 8 bits of an output port. Connect the clock pulse input to the computer's output strobe line. Remember to program the computer to include the correct digit address in each data output. For use with hexadecimal data, use a substitute for the 7448 which decodes hexadecimal 7 segment patterns.■

Figure 5b: Printed circuit component side map of the display matrix. The LED parts are MAN 4 or DL704 seven segment displays or their equivalents.



Continued from page 121

recommend that a short program be written to cycle the cassette output between a one and zero every few seconds. Connect a frequency counter to the output and readjust the mark and space pots to the correct specifications. I also noticed that variations in power supply voltages from one time to the next can adversely shift this frequency. Having an adequate well designed power supply will limit variabilities even as more memory is added. My 10 K system draws approximately 4.4 A at 5 V and with 18 K on it; it now takes 5.7 A.

The last comment is no Digital Group problem, but rather mine. I assembled the 10 K memory board as instructed, plugged it into the system and ran the DGS memory test program for a couple of hours. It all checked out fine, but when I tried to read any program which occupied 10 K of memory (2 K worked fine) it bombed out. Since the memory test program said the memory was fine, I was led to suspect the 10 K BASIC tape. I shipped that tape off to a friend to try it on his DG system and contacted the Digital Group software people for a new tape. Within five days I had both a new tape from DG and confirmation from my friend that I had a problem because the tape was OK. But the memory test said the memory was OK! Well, don't believe it! In the process of removing and checking each 2102 on my 8008 system I found an IC with a pin bent under it. Straightening this pin and reinserting the 2102 was all that was needed, and the Tiny BASIC read and executed perfectly. Be careful of memory test programs.

In conclusion, my experiences with the Digital Group 8080A System have been gratifying. My system worked with no major problems, and any intelligent user either constructing the computer in whole or part should expect the same. The fact that I now have an operational microcomputer has caused a slight problem, though. I never get to use it! I seem to continually have people from my office over in the evenings programming one thing or another. In fact, I had to add another 8 K this week to allow more Tiny BASIC programming space for one guy who is writing a statistical program which he hopes will help him win at jai-alai. I suggest that if you get one of these small computers, just walk around with a pleasant pregnant smile, but for heaven's sake don't tell anyone that it really works!■

[Watch for Steve's humorous account of jai-alai in April's BYTE.]

Another

START HERE

SCAN DIRECTION

PAPERBYTES ™ Test

As noted in last month's BYTE, page 121, we had intended to have an extended text included in the magazine for February. The text got delayed, due to a combination of human, weather and Murphy's Law Factors. This month, it arrives at the printing presses for publication.

This text is an extended set of ASCII encoded English language words. The bit level format is format 3 (compressed ratio recording) as described in previous articles on the subject in BYTE November 1976, page 10, and BYTE December 1976, page 12. In this format, the width of the bars and spaces are encoded as follows: space = 1 unit width; zero bit = 1 unit width bar; one bit = 2 unit width bar. The frame format begins with an ASCII SYN (10010110) character extended to 8 bits with a high order 1 bit. The frame continues with 8 bits of check sum, 8 bits of line identification, and 8 bits of byte count. The byte count sets the number of data bytes which follow the header.

Add Some Zest by Making a Contest

Rather than just print another test, we decided to make this text sufficiently complex to warrant making a small contest out of it. Within the frame format we have encoded the plain text of ASCII upper and lower case characters (plus line control) defining Walter Banks' parody of a famous poem dealing with mythical critters and strife and conquests. Lewis Carroll purists will object to the arbitrary and incomprehensible semantic transformations made on the arbitrary and incomprehensible semantics of the original, but the necessities of making a contest required uniqueness: This version has never been published before and it is completely different at the detail level. All contests have ground rules, and here are the ones which apply to the first (and probably only) PAPERBYTES Contest:

- Entries must be received in our office by March 31 1977. They should be addressed:

  BYTE magazine
  Attention: PAPERBYTES Contest
  70 Main St
  Peterborough NH 03458

• Each entry should contain a stamped self addressed envelope (as well as redundant identification of the contestant) in the event materials are not used by our office in the publication.
• Each entry must contain the completely decoded text, either as a printed text listing (upper and lower case) or as a hexadecimal absolute data listing with one line per line of bars. Handtyped listings are fine, if you don't have a hard copy device.
• Each entry must be accompanied by a complete and detailed technical description of the system used to decode the text. Hand decoding is not an acceptable method. Brownie points in the judgment of entries will go to the least expensive systems (other things being equal).

While it is not necessary to treat entries as a formal technical article submission, winners and runnersup in the competition may be published with payment at our current rate for highly desired technical materials.

The Prize?

A check for $100 will be the bonus for the winning entry in this contest, as judged by BYTE's editor Carl Helmers based upon materials submitted.

A Note About Formats, Coming PAPERBYTES Items, etc.

In this sample text, we do not provide the equivalent human readable form of materials. This is due to the nature of this month's test which is being treated as a contest. The arrow identifies the beginning of the text.

Normal practice when publishing programs in BYTE is expected to include printing of a complete hexadecimal object text for programs as a confirmation of the bar coded machine readable texts. Production problems notwithstanding, the first program we expect to print in this form will appear as bar codes in the May 1977 BYTE in the second part of Jack Emmerichs' article on his "Tiny Assembler" for the Motorola 6800. We've been using Jack's assembler (we = Walter Banks at the University of Waterloo, Carl Helmers at BYTE, Chuck Adams at Texas A&M University) since late in 1976. Also planned for future release in this form are additional

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systems software programs for the popular processors.

What About Source Code?

When publishing object code for extended programs, such as Jack's assembler, or a BASIC interpreter or other software, the length of the source listings preclude reproduction in the magazine. The source code of the Tiny Assembler runs 40 pages for example. To provide the source code for those individuals seriously interested in modification and extension of programs of this form, PAPERBYTES will be making available extended documentation for programs including users manual information, source listings, a reprint of any BYTE articles discussing the programs, and additional documentation depending upon the type of program being published. The PAPERBYTES release of Jack Emmerichs' assembler user's manual is in preparation coincident with preparation of his articles for publication.■

Attention, Engineers of Bar Code Readers:

On page 320 of the November 20 1976 issue of *EDN* magazine, there is a short note sent in by Wesley Grenlund of Beloit Corporation, Rocton IL, concerning a signal processing circuit for scanners. The circuit combines a Texas Instruments TIL139 source-receiver assembly with the 75140 line receiver to make a TTL level input to the single bit port needed by bar code scanning software. The only additional part probably needed is some slit optics (.01 inch [.0254 cm] wide for our bars) to define a limited active area. The slit would be positioned in front of the intersection point of the source beam and the receiver viewing path, as suggested by Dave LeVine.

We received a similar hint to use the TIL139 in early October from Dave (who is chief engineer of Computer Link, Burlington MA). Dave says he has successfully used the TIL139 together with a single National Semiconductor 74C14 hex Schmitt Trigger integrated circuit as the sole input processing amplifier: This version uses one of the Schmitt triggers in the package as a capacitively coupled amplifier (open loop and saturating), with the remaining five triggers ganged in parallel to drive a TTL unit load from the output of the first trigger. This hint popped out of Dave in the context of the usual "micro session" (would be called "bull sessions" in any other field) which occurred at the October 1976 meeting of the New England Computer Society.■

BYTE's Bits

Guinness, Take Note:

The World's First Commercial Personal Computing System Product to Use 16 K Dynamic Programmable Memory Chips . . .

A recent phone call from Steve Jobs (who, with Steve Wozniac, is responsible for the Apple Computer Company) reported what is claimed to be the first shipment of a personal computer systems product built with the new 16 K dynamic memory chip products. The product which used these chips was an Apple I – an MOS Technology 6502 proccessor board with 32 K 8 bit bytes of memory (16 chips), read only memory systems software, and video interface. The board was delivered to one of the Byte Shops in the San Francisco Bay area on December 17 1976, for sale to a retail customer.

Larger and larger amounts of memory will be the trend in small computer systems for some time, due to the combined factors of its immense desirability as a programming resource and the dropping prices of the new LSI semiconductor technology. The use of the 16 K chips in Apple was made possible by the fact that the manufacturer of these memory parts chose to make the 16 K designs essentially pin compatible with their older 4 K designs by using a change in the logical interpretation of one of the lesser used pins of the package. This pin now serves as the seventh address bit in each of the two 7 bit address segments which form the 14 bit address needed for a 16 K bit array. The Apple product demonstrates the success of this idea since it will take any combination of 4 K and 16 K chips in byte wide groups. Watch very shortly for advertisements of the new Apple II computer, both as a finished product and as a board level computer which looks like it will be an excellent and innovative addition to the marketplace. ■

A HAM Swapfest

The 7th Annual North Florida Swapfest sponsored by the Playground Amateur Radio Club (PARC) will be held in Fort Walton Beach FL at the Okaloosa County Shrine Fairgrounds on Saturday, March 19 and Sunday, March 20 1977. The Swapfest will be a full weekend affair with the display area open from 8:00 AM to 4:00 PM each day. A dinner, featuring a prominent speaker, will be held at the Fort Walton Beach Holiday Inn Saturday evening. The North Florida Swapfest is an annual event, sanctioned by the American Radio Relay League (ARRL), and draws hundreds of Radio Amateurs and electronics experimenters primarily from Louisiana, Mississippi, Alabama, Georgia, and Florida, although

amateurs from many other states attend.

The North Florida Swapfest is a nonprofit function and proceeds are used to finance local Amateur Radio projects, the next year's Swapfest and the Playground Amateur Radio Club Scholarship Fund. Interested in information on booths or attendance? Contact Bill Callanan WB4FTA, Swapfest Chairman, Playground Amateur Radio Club, POB 433, Fort Walton Beach FL 32548.■

A Mention

MICROCOMP is a new computer store, dealer of OSI products, located at 785 S Main St, Fond du Lac WI 54935. Phone (414) 922-2515, or write Nyles Priest of MICROCOMP.■

BYTE's Bugs

Why the DACs "Don't Work"

Author Steve Ciarcia sent our way (via his friend Chris Morgan who stopped by one recent Saturday) the following correction to his article "Make Your Next Peripheral a Real Eye Opener" on page 78 of November 1976 BYTE. In the schematic of pages 84 and 85 (figure 2), we (Steve or CH at BYTE? Who knows?) omitted notation of the negative supply pin for the MC1408-L8 digital to analog converters, IC4 and IC5. Pin 3 of each 1408 should be wired to the −15 V supply.■

Weathering the Storm

Author Mike Firth, whose article "Do It Yourself Weather Predictions" appeared on page 62 of December 1976 BYTE, sends in the following items:

In my article on the weather, a call from Tom Harper in Miami FL has put me on the track of two problems, which I describe below:

On page 66 (BYTE December 76), the simple formula for relative humidity (H=100% − T*5) is said to be for centigrade temperatures, but in fact it is for Fahrenheit, an error caused by an error in my original source. To use the equation for centigrade temperatures, the 5 should be changed to an 8.

In using the more complex formula, three different values of E, the vapor pressure, must be used, but my article made it seem that only two were needed. Two are obtained from a table or by interpolation from the values given at the top of page 66. They are E_W, the vapor pressure of water at the wet bulb temperature, and E_d, the vapor pressure of water at the dry bulb temperature. The third value is E, the actual vapor pressure in the air from the formula. The proper formula for relative humidity is then:

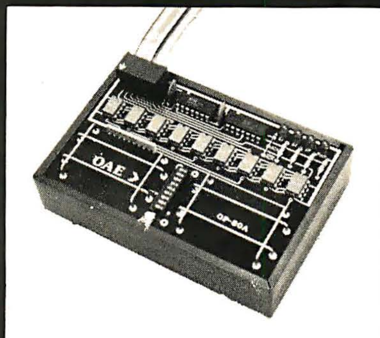
$RH = E/E_d$ (not $RH = E/E_W$ as given in the article).■

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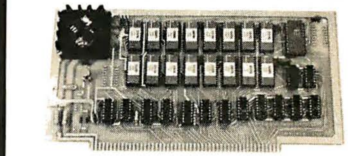
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FOR SALE: Attention computer hams: Morse to ASCII decoder. All controls accessible from front panel. Work with TVT 1 or TVT 2. I have helpful documentation on the decoder that I will pass along on request for $1.50 to handle cost of photo copies and postage. Asking $75 for the unit. Write Jack S Davis, POB 5, Endwell NY 13760, (607) 754-0309.

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FOR SALE OR SWAP: Texas Instruments SR-52 card programmable calculator, complete with all standard accessories and manuals. It has a special programming manual with many programming tricks, procedures for accessing 60 data memories, and procedures for reading and writing data onto cards, $200 or fair trade for S100 bus, Altair-IMSAI, compatible memory or IO. R W Toy, 155-A Duncan, San Francisco CA 94110, (415) 648-6105.

WANTED: November 1975 issue of BYTE. Will consider purchase or trade for this issue only, or possibly, for a set of issues. Chris Bauer, IEMS Dept, Florida Technological University, POB 25000, Orlando FL 32816, (305) 275-2236.

FOR SALE: Friden Flexowriter Baudot Teletype with five level paper tape punch/reader plus card reader. Can be converted to ASCII, $95. Derek Hendry, 64 The Uplands, Berkeley CA 94705, (415) 654-5583.

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Please note that it may take three or four months for an ad to appear in the magazine.■

WANTED: Software and hardware schematics for music synthesizers (computer controlled or not). I am especially interested in automated music composition. Bill Struve, 505 Meade Cir, Memphis TN 38122.

WANTED: *SCCS Interface* issues December 75, February 76 and March 76. Please let me know if you have them for sale. Thomas R Baley, 279 Gehring Rd, Tolland CT 06084, (203) 872-7084.

FOR SALE: Mostek F-8 evaluator kit fully assembled and working with literature. Two complete Viatron 2100 systems working with the complete literature pack. The first check (certified) or M O for $900 takes all. Donald E Scherck, Rt One, Collbran CO 81624.

SITUATION WANTED: Research physicist, with several years practical digital design experience, breadboarding, prototyping, etc; thorough reading knowledge of microprocessors and software. Looking for position with computer store, computer consultants or similar, in which my abilities can be traded for salary and chance to learn micros. Jay Kirschenbaum, 350 E 30th St, Apt 4L, New York NY 10016, (212) 684-5525.

NEED: BYTE issues 1, 2, 3, 8, 9 and 10. Willing to swap money for them, but have surplus copies of other issues of BYTE as well as assorted test equipment and digital hardware and components. How about a handful of 2102s? Hank Irvin, Dept of Physics, Tulane University, New Orleans LA 70118.

WANTED: I will buy your new, used, or dead Altair 8800, working or not, for cash. I am desperate for Altair. Help out a poor college kid. I will also trade for your machine. I have a scope and a Teletype. Call anytime. Jim Webb, POB 5224, Carson CA 90749, (213) 325-4684.

FOR SALE OR TRADE: PDP-8 mini-computer (straight-8), mounted in attractive walnut cabinet (spouse-approved for den). Complete with maintenance manual, drawings, 4 K BASIC, 4 K FOCAL, editor, PAL III assembler, disassembler, TTY interface, games, etc. Perfect condition. Free DECUS membership available for additional software. Presently in use with ASR model 33 Teletype. Can be sold with or without model 33. Sale price W/O Teletype $800. Rex Engle or Jim Speidel, POB 10498, Charlotte NC 28288, (704) 374-6409.

TERMINALS: BURROUGHS 9350-2, ASCII, 15 cps upper and lower case, $200. Friden Flexowriter, model SPS with paper tape reader and punch, $200. Univac DCT500, 30 cps printer, no power supply or interface, $100. Phil Hughes, POB 2847, Olympia WA 98507.

FOR SALE: Altair 8800 system with 8 K RAM, 88-SIOA, 88-ACR, 8 K BASIC, assembled and running, $1167. SWTP CT-1024 complete, unassembled, less monitor and case, $275. Friden ASCII communications terminal from Herbach and Rademan with control unit, $200. Chris Foreman, POB 127, Reseda CA 91335, (213) 342-8845.

WANTED: BYTE issues for October and November 1975; April, May and June 1976. Please notify the following indicating price desired: Technical Library, Bell Telephone Laboratories, Western Electric Co, 2525 Shadeland Av, Indianapolis, IN 46206.

FOR SALE: Cryptographic program that will baffle the codebreakers of the CIA. Encode and/or decode your private correspondence for maximum security. Documentation of cypher technique, program listing and punch paper tape in BASIC for only $6. Jon Stedman, 1528 Summit Rd, Berkeley CA 94708.

FOR SALE: Pacer: a 16 bit micro with TTY interface, line assembler in ROM and complete documentation. Assembled and running in cabinet with 32 key control assembly. Call (213) 243-5179 or write POB 430, Glendale CA 91206.

WANTED: Back issues of BYTE. Desire 1 copy each of issues 1 through 14. Will pay $3 for each complete issue in good condition. Call (313) 323-3574 or write R Parenteau, 11020 Burlington #409, Southgate MI 48195.

WANTED: Back issues of BYTE magazine: issues 2, 3, and 8. Please send price and condition information to Art Leyenberger, 142 Kenilworth Rd, Ridgewood NJ 07450.

WANTED: BYTE magazine issues 7, 8, 9 and 10 in good condition only. Frank E Marfai, 2839 Hermosa Av, La Crescenta CA 91214.

FOR SALE: Brand New ASR-33 Teletype with auto reader. I reconfigured in midstream and will sell this superb $1,188 value for only $950. Immediate delivery instead of usual 4 to 6 month wait. J Katz, 1921 Pelham Av, Los Angeles CA 90025, (213) 474-3347.

FOR SALE: Altair 8800 computer, well built and checked out, $500. Two MITS 4 K RAM boards, $150 each. One PTech 4 K RAM board, kit untouched, $120. One 4 K x 8 EPROM board with assembled monitor, $150. One MITS RS/232 S10 board, $100. SWTPC TVT 2 with 510 and PS and keyboard and monitor, $300. SWTPC cassette interface well built unchecked, $70. 32RO TTY new, $300. Best offer takes any or all. Louis Doctor, BARH D311, RPI, Troy NY 12181, (518) 270-7586.

CHANGING HOBBIES: Want to swap miscellaneous ham gear for computer and/or peripherals. Have Heath SB-303 with optional crystal filter and other items too varied to list. Also have near new Heath stereo mike mixer and miscellaneous test equipment, all in good condition. Also willing to swap professional (First Class Federal License) assembly service or technical assistance for devices. Call or write Mike Hales, Route 1, POB 30W, San Juan TX 78589, (512) 383-7233.

WANTED: Manual or schematics and timing information for IO circuits of IBM model 72 Selectric typewriter/terminal. C G Bothner, POB 153, Landing NJ 07850.

FOR SALE: Tektronix model 611 graphics storage display scope, $450. Also have Tektronix model 581 oscilloscope with type 82 plug in and scope mobile, $400. Will trade for Altair 8080. Don Heinlein, 1546 E 215th Pl, Carson CA 90745, (213) 830-4225.

FOR SALE: Altair 8800a, 16 slot memory board, fan; two 4 K dyn, two 4 K static, (16 K total memory); ACR IO; 3P+S IO; TVT II with 64 characters per line; SCM Telewriter; software. $2150. Will separate. Evenings: (312) 328-5610.

FOR SALE: GE core memory 16 K by 40 bits, all power and interface circuitry and documentation — been used with an 8080 processor. Litton Industries drum memory with full read write electronics. Bryant MBM drum memory. By unit or best offer over $250 for lot. C H Eby, 7101 Mammoth Av, Van Nuys CA 91405, (213) 988-1763.

FOR SALE: Microprocessor system by Control Logic. Contains three basic cards; central processing unit using an 8008 input output control providing clocking and processor control signals, and memory address storage which provides latching registers for memory and output data control and a 256 byte PROM. Also included: 1 K of 2102 RAM, card mounting hardware, and logic diagrams, $100. K Talen, 10605 Double Spur Loop, Austin TX 78759, (512) 258-4282.

FOR SALE: PolyMorphic VTI 64 video module, 64 characters per line, keyboard input port, Greek control characters, $200. Morrow's Godbout Cassette Interface (BYTE Standard) fully expanded, with 3 cassette channels, parallel and RS-232 TTY IO ports, and operating system in EROM, $120. Both boards assembled and working with ICs in sockets, and postpaid in continental US. Shipped within 24 hours of receiving MO or certified check. Tom Burke, 150 Church St, Burlington VT 05401.

MICRODATA REALITY: Are there any other computer hobbyists using this system? If so, I'd like to say hello, swap notes and programs, etc. Would also like to know where to buy a 4 or 8 way video terminal interface card and other peripherals for Microdata Reality (Model 1600 processor). Jack Hardman, 140 Forest Av, Glen Ridge NJ 07028, (201) 429-8880.

ST. LOUIS

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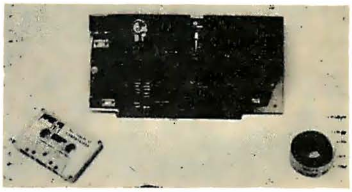
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Clubs and Newsletters

Conducted by
Peter Travisano

HP-65 Users Club

The HP-65 Users Club is by, of and for those people around the world who use and enjoy Hewlett-Packard calculators. Its newsletter *65 Notes* is a must for anyone stuck on these machines. Volume 3, Number 9, is a special games and programs issue. HP-25 Roulette is a mathematical duplicate of the Monte Carlo original, complete with broken bank. Depending on your imagination or your friends' bank accounts this program could conceivably save airfare to Las Vegas. Another program for your HP-25 is Battleship II, a game which starts with random shooting at your opponent's hidden fleet until a discernible pattern appears; after that, it's a race to sink the enemy's ships as quickly as possible. Number Guesser is a handy way to decide all kinds of distasteful things like whose car do we take or who pays for lunch: sort of an electronic short straw.

There are plenty of other games and ideas. So if you want to get the most out of your Hewlett-Packard calculator, be sure to send for more information from the HP-65 Users Club in care of Richard J Nelson, 2541 W Camden Pl, Santa Ana CA 92704.

Dayton Microcomputer Association Formed

Looks like Dayton OH hackers are off to a fine start with well over 100 hobbyists working together to form a new club.

Meetings take place on a regular basis, 7:30 PM on the last Tuesday of each month. For more information write Dayton Microcomputer Association, in care of Dayton Museum of Natural History, 2629 Ridge Av, Dayton OH 45414.

Montreal Micro 68 — Club des Mordus d'el Ordinateur — Computer Club

The world's first bilingual computer club has been organized in Montreal. Among other projects, Micro 68 plans to exchange computers, hardware applications and software with other clubs in the US. For more information, get in touch with John Courtney, president, Montreal Micro 68 Computer Club, Case Postale al Succur Sale, Montreal CANADA H4Y 1A2.

Denver Amateur Computer Society — INTERRUPT

There are newsletters and there are newsletters, but DACS' fine publication, *INTERRUPT*, ranks with the superb handful that begin to invade the area of the print media set aside for magazines. There are plenty of interesting and competent features on micros.

Dealing with DACS is a good way to learn more about computers; they'll even help you get a club started in your area, which is probably the best way to share and spread knowledge.

Interested? Get in touch with the Denver Amateur Computer Society, POB 6338, Denver CO 80206.

Analytical Engine — Chesapeake Microcomputer Club Inc

Another newsletter that has helped set the standard in the micro hobbyist field is the *Analytical Engine*, the publication of the Chesapeake Microcomputer Club Inc, 236 St David Ct X-4, Cockeysville MD 21030, (301) 667-9690.

Those still looking for a basic Star Trek program might want to get hold of Volume 1, Number 6. They will also find an elementary article on kit building and another on assembling a five chip interface for those a little further along. The same issue contains a "Bibliography of Microprocessor Sources," as a handy reference of books, software, periodicals and articles. They also list similar bibliographies if this compendium isn't enough.

ON LINE — Hardware and Software Exchange

The *ON LINE* people continue to publish a listing of classifieds geared to the computer hobbyist: everything a hacker could want for sale or swap, you name it. There's also a listing of clubs, with meeting schedules. If you want to place an ad or if you're just looking for a bargain, send a note to *ON LINE*, D H Beetle, publisher, 24695 Santa Cruz Hwy, Los Gatos CA 95030.

Southern New England — Westchester — Fairfield

We often mention NECS, the New England Computer Society, in these pages; but New England is a fairly large area with more than its share of computer buffs, especially in its southern parts. If you're a

Connecticut or Westchester hacker, you might want to drop a line to one of these addresses: Southern New England Computer Society, 257 Willow St, New Haven CT 06511; Connecticut Microists, 8612 Wendy Ln, Westport CT 06800; or Westchester-Fairfield Amateur Computer Society, RR 1, POB 198, Pound Ridge NY 10576.

Japan

Thanks to the Homebrew Computer Club in Mountain View CA, we have a rather exotic address: that of the Japan Microcomputer Club. Those visiting that part of the world may want to stop in at the First Ohkura Building, 4f 2-1 Nihoubashi, Chuo-ku Tokyo JAPAN.

CACHE Register, Chicago

The Chicago Area Computer Hobbyists Exchange continues to publish *CACHE Register*, a newsletter that seems to lean toward abstract information on hardware and software; that is, there is very little editorializing, just the facts.

The people at CACHE are always glad to lend a hand to the hobbyist who needs information of any kind. Write to CACHE, POB 36, Vernon Hills IL 60061.

Minnesota Computer Society

We've had some correspondence from a new group (new at least to BYTE), the Minnesota Computer Society. Those in the Twin Cities area who would like to get together with other hackers should drop a line to MCS, POB 35317, Minneapolis MN 55435.

The Association of Time-Sharing Users

Here's a unique and really useful group for those involved in timesharing. AT/SU is dedicated to organizing and providing information and a forum for the users and industry representatives of remote computing. They publish a newsletter, *Interactive Computing Press Review*, a compilation of pertinent articles from various sources; *Interactive Computing Directory*, a two volume directory of remote computing users and suppliers updated with each newsletter; and *Special Reports*, a consumer's guide to timesharing services. Write the Association of Time-Sharing Users Inc, 75 Manhattan Dr, Boulder CO 80303.

Clubs and Newsletters information should be sent to BYTE, 70 Main St, Peterborough NH 03458, attention Peter Travisano.

Philadelphia Area Computer Society

PACS is publishing a newsletter called *THE DATA BUS*. Among the features is a reprint of Dr Lance Leventhal's fine series of tutorial articles on microprocessers, beginning in November. Bill Goble is writing a three piece article entitled "Small Computer Bus Structure," which promises to be a fairly comprehensive series on bus signals and receiving and transmitting the bus. For information concerning the Philadelphia Area Computer Society and *THE DATA BUS*, get in touch with Bill McGill, University of Pennsylvania, Moore School Computing Facility D-2, Philadelphia PA 19174.

Mobile, Alabama — Anyone Interested in . . .

. . . SOL-10 Terminal Computers? R Downs is and he's looking for other folks who are, too. Contact Mr Downs at 205 Shelton Beach Rd, #53, Saraland AL 36571.

New York Amateur Computer Club

Hackers in and around "Fun City" might want to look into the advantages of joining the New York Amateur Computer Club in care of R Schwartz, 1E 375 Riverside Dr, New York NY 10025.

Ottawa

The Ottawa Computer Group has grown to substantial proportions in a rather short time. To get in on their doings, stop in at the National Research Council, 100 Sussex Dr, Ottawa, on the first Monday of the month or write POB 13218, Kanata Ontario, CANADA K2K 1X4, (613) 233-9412.

St Louis Area Computer Club

The St Louis Area Computer Club met recently for the first time, attracting hackers from both sides of the Mississippi. Apparently we have a real mix here of ages, vocations and obscure computers. To find out more, contact Lou Elkins, POB 1143, St Louis MO 63188, (314) 427-6116.

Panhandle Computer Society

We've just received word that a new computer club has formed, The Panhandle Computer Society of Amarillo TX. They meet every Friday and boast a membership of more than 30. All inquiries should be addressed to Tex Everett, 2923 S Spring, Amarillo TX 79103, or call (806) 373-8307.

A Note from Sol Libes re a National Personal Computing Society

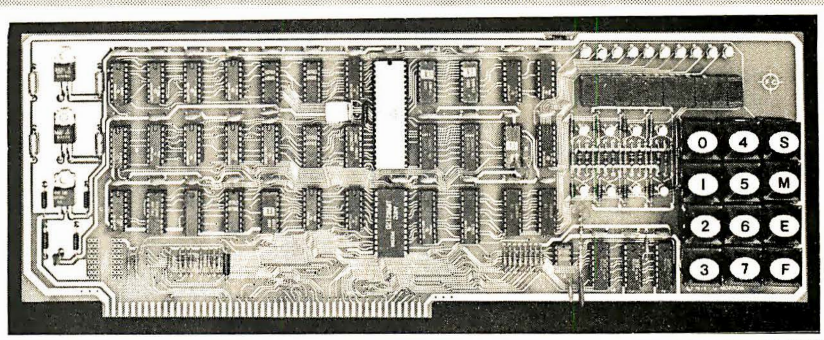
I have just finished reading "Some Notes on Clubs" in the August 1976 issue, page 4, and must take exception to the statements you attributed to me. I fear there must have been a misunderstanding in our discussions. I certainly did not say, in regard to a national organization: "Who needs it?", etc.

I frankly feel there is a need for a national organization similar to ARRL. There are many reasons for it. Primary among them is the need to develop standards, both for hardware and software. We are currently faced with the problems of many manufacturers going their own way in equipment and program design and hence a great deal of noncompatibility. This causes unnecessary expenses for the amateur user. For example; we currently have more than a dozen different cassette IO systems which are not compatible. This greatly inhibits the exchange of software in cassette form. Adherence to one recording standard would eliminate this problem.

A single club, or regional organization, is not in a position to develop standards and influence their adoption. This can only be done by a national organization.

Sol Libes, President
Amateur Computer Group of NJ
UCT1
1776 Raritan Rd
Scotch Plains NJ 07076

Sorry about the misunderstanding, Sol. I came away with the impressions printed in that issue . . . CH.■



BYTE's Bits

Jim Warren's Official Rumors About the West Coast Computer Faire . . .

In phone conversation January 5 of this year, Jim Warren mentioned some of the plans for the banquets which will be held during the First West Coast Computer Faire. On Friday and Saturday night of the event, there will be speakers. Each night's offering will represent one speaker about the future world, and one speaker commenting about the real world of today. On Friday April 15, the real world speaker will be John Whitney, the computer animation and graphics artist who provided a fascinating show at the Personal Computing 76 show in Atlantic City last fall. The future world speaker on Friday night will be Frederik Pohl, one of the better known contemporary science fiction writers. On Saturday April 16, the real world speaker is Dr Henry Tropp, who will speak about his recently completed research project on the history of computing, commissioned by the Smithsonian Institution. The future world speaker for Saturday's banquet had not been finalized as of the time this note was written.■

Want a Used Computer?

Believe it or not, there exists the friendly local used computer broker — and there are enough of these fellows around apparently (13 in 13 different cities) to warrant a somewhat classy service organization run by Arthur F Phinney and called the Computer Multiple Listing Service, located at 3212 Chichester Ln, Fairfax VA 22030. This organization puts out a 16 page pamphlet which describes some of the mechanics of computer brokerage and the ways in which computer purchases can be arranged. We wouldn't expect much traffic in $2000 personal systems here, but if you want to look into a bargain price for a model X big computer this might be the place to start.■

Notes on "What Is It?"

In December 1976 BYTE we ran a little query on page 96 concerning a cross section of an unidentified product. The answer appeared in the January 1977 issue of BYTE on page 104. The question elicited several responses, but only one correct response. Floyd Largent, of the Abex Corporation, Engineered Products Division, Mill St, Athens OH 45701 writes: "The product in your "What Is It" photograph is a porous plastic used to hold ink for computer printout devices."

But some of the wrong answers were just as interesting as the picture itself. Two people identified the item as a scanning electron microscope picture of a printed circuit board. One person identified it as an electron microscope picture of "the actual atomic lattice of a conducting material, copper wire or something . . . " (Only problem: Resolution for typical electron energies is just not that good.) One person opined that it was "an experimental optical read only memory consisting of microencapsulated spheres of a black fluid sandwiched between two transparent planes. A relatively high power beam of light is used to write bits by exploding a sphere containing the fluid, while a low power beam reads the blots created as bits." Another identified it as a cross section of a bubble memory. The most common answer, which actually is not far from the mark, was that the picture was a cross section of the commonly used conductive foam in which integrated circuits come packaged. In appearance, it is probable that a closeup photo of such foam might indeed look very similar to the photomicrograph of the inking matrix.

We extended Floyd's BYTE subscription by one year as an informal prize on this informal contest.■

Attention Manufacturers

Personal computing equipment manufacturers and suppliers are invited to participate in the 1977 National Computer Conference personal computing exposition to be held in Dallas TX, June 13-16. The NCC, sponsored by the American Federation of Information Processing Societies Inc (AFIPS) and four of its member societies, will be the year's largest gathering of data processing users and computer professionals.

Full information on the Personal Computing Exposition, including brochure, floor plan, and application forms, is available from the AFIPS Exhibit Sales Office, 210 Summit Av, Montvale NJ 07645, (201) 391-9810.

The 77 NCC, recognizing the size and importance of the personal computing market, will feature a commerical exhibition by equipment manufacturers and suppliers of personal computing products and services. The Personal Computing Exposition will be in the North Hall of the Dallas Convention Center one level below the main NCC exhibit hall. Reservations for linear booths (minimum size 10 feet by 10 feet at a cost of $600) are currently being accepted. As a special service to participating exhibitors, packaged booth displays are being made available as part of the overall cost.

In addition to the Personal Computing Exposition, the NCC will also feature a Personal Computing Fair where individuals and groups will display noncommercial systems and equipment. Personal computing will also be covered in a variety of NCC events including a two day program of sessions, and a computer club congress.■

Programmers Invited to Participate in 1977 National Computer Conference Programming Contest

This announcement arrived two days after the February BYTE was on the press, but if you hurry, you'll be able to meet the March 1 deadline . . . by writing your own "official entry form" as well as the contest entry.

Programmers who attend the 1977 National Computer Conference, June 13-16, in Dallas TX will have an opportunity to participate in the 1977 NCC National Programming Contest. All contestants will be competing for prizes, trophies, and plaques, as well as the chance to gain the title of "1977 National Champion Programmer."

According to Dr Portia Isaacson of the University of Texas at Dallas, 1977 NCC chairperson, "The 77 NCC special activities committee has organized this 'first' National Programming Contest in an effort to involve computer professionals more directly in conference activities. Approximately 240 applicants will be selected to participate in a test of logic and programming skills."

Directing plans for the contest is Dr C E Rodriguez of East Texas State University. Dr Rodriguez reports that there will be no requirement for a particular programming language. Entrants selected will receive a list of specific languages, terminals, and timesharing services to be used in the contest. Contestants will be selected based on the quality of their solutions to a sample problem which will be made available on request.

Deadline for all entries is a postmark no later than March 1 1977. Official entry forms and sample problems may be obtained by writing Dr C E Rodriguez, Computer Science Dept, East Texas State University, Commerce TX 75428.■

A New Virginia Polytechnic Institute Seminar Program

David G Larsen forwards these two notices of a new series of microprocessor related seminars to be held at VPI in June of this year:

> *Microcomputer Interfacing Workshop*, June 9, 10, 11, 1977.
> A three day workshop based on the popular microprocessor. Over 20 operating 8080 computers are available for participant use.
> *Digital Electronics for Automation Workshop*, June 7, 8, 1977.
> A two day workshop based on the small scale and medium scale TTL integrated circuits. Many hours of laboratory time with individual breadboarding stations will be provided along with indepth lectures.

For more information on these workshops contact Dr Norris Bell, VPI and SU Continuing Education Center, Blacksburg VA 24061, (703) 951-6328.■

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CSC No.	Length, Ins.	Terminals*	Mtg. Dimensions, Ins.	List Price
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QT-59S	6.5	118	6.2 x 0.7	$12.50
QT-47S	5.3	94	5.0 x 0.7	10.00
QT-35S	4.1	70	3.8 x 0.7	8.50
QT-18S	2.4	36	2.1 x 0.7	4.75
QT-12S	1.8	24	1.5 x 0.7	3.75
QT-8S	1.4	16	1.1 x 0.7	3.25
QT-7S	1.3	14	1.0 x 0.7	3.00
QT BUS STRIPS				
QT-59B	6.5	20	6.2 x 0.7	$2.50
QT-47B	5.3	16	5.0 x 0.7	2.25
QT-35B	4.1	12	3.8 x 0.7	2.00

*Groups of five pre-connected tie-points.

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PROTO-BOARD 100 KIT

Contains two preassembled QT-35S sockets, one preassembled QT-35B bus strip, two 5-way binding posts, non-metallic base plate, non-marring feet and all hardware. Ten minute assembly time. Size: 4.5" w. x 6" l. x 1.4" h. Weight: 7.5 ozs.
CSC Model PB-100 Kit—Complete. List Price $19.95

PROTO-BOARD 101

Fully assembled breadboard contains two QT-35S sockets and four QT-35B bus strips mounted on metal ground/base plate with non-marring feet. Excellent for audio and small digital projects. Size: 5.8" l. x 4.5" w. x 1.4" h. Weight: 9 ozs.
CSC Model PB-101 Breadboard—Complete. List Price $29.95

PROTO-BOARD 102

Fully assembled breadboard contains two QT-47S sockets, three QT-47B bus strips and one QT-35B bus strip on a metal ground/base plate with non-marring feet. Excellent for intermediate digital needs. Size: 7" l. x 4.5" w. x 1.4" h. Weight: 10 ozs.
CSC Model PB-102 Breadboard—Complete. List Price $39.95

PROTO-BOARD 103

Fully assembled breadboard contains three QT-59S sockets, four QT-59B and one QT-47B bus strips, four 5-way binding posts on a metal ground/base plate with non-marring feet. Build calculators, interfaces, networks, etc. Size: 9" l. x 6" w. x 1.4" h. Weight: 1½ lbs.
CSC Model PB-103 Breadboard—Complete. List Price $59.95

PROTO-BOARD 104

Fully assembled breadboard contains four QT-59S sockets, seven QT-59B bus strips and four 5-way binding posts on a metal ground/base plate with non-marring feet. Build a CPU, encoder, complex display, etc. Size: 9.8" l. x 8" w. x 1.4" h. Weight: 1¾ lbs.
CSC Model PB-104 Breadboard—Complete. List Price $79.95

PROTO-BOARD 203

Fully assembled breadboard contains built-in, short-proof, fused, 5 VDC at 1 amp, regulated power supply, in addition to three QT-59S sockets, four QT-59B bus strips, one QT-47B bus strip and four 5-way binding posts. Capacity for most digital and many analog projects. Size: 9.75" l. x 6.6" w. x 3.25" h. Weight: 5 lbs.
CSC Model PB-203 Breadboard—Complete. List Price $75.00

PROTO-BOARD 203A

Provides all the features of Proto-Board 203 with additional +15 and −15 VDC at 0.5 amp power supplies with internally adjustable output voltages. Size: Same as PB-203. Weight: 5.5 lbs.
CSC Model PB-203A Breadboard—Complete
List Price $120.00

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A compact, versatile design and test tool for digital applications. By simply connecting the clip leads to the circuit power supply, setting the logic family switch to the proper position (TTL/DTL or CMOS) and touching the probe tip to the IC pin in question, the LP-1 will give an instant picture of circuit conditions. Two level detector LED's (HI for logic "1" and LO for logic "0") and a blinking PULSE detector LED display the signal activity. One-shot, low-repetition-rate, narrow pulses are stretched to ⅓ second. A PULSE/MEMORY switch allows one shot events positive or negative transitions to be stored indefinitely. High frequency signals cause the PULSE LED to blink on and off at a 3 Hz rate. When the high frequency signals are unsymmetrical, there is an additional indication. Duty cycles less than 30% activate the LO LED; duty cycles above 70% activate the HI LED. Input Impedance: 100,000 ohms. Threshold: DTL/TTL, 2.25 V ±0.15 V equals "Logic 1", 0.80 V ±0.01 V equals "Logic 0"; HTL/CMOS, 70% of Vcc equals "Logic 1", 30% of Vcc equals "Logic 0". Minimum Detectable Pulse Width: 50 nanoseconds. Input Frequency: Up to 10 MHz. Input Overload Protection: ±50 V continuous; 117 VAC for less than 15 seconds. Size: 5.8" l. x 1.0" w. x 0.7" d. Weight: 3 oz. Power Required: 30 mA at 5 VDC, 40 mA at 15 VDC, 30 V max. with polarity reversal protection.
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Photo of expanded EVK 99
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   To implement fully expanded system additional IC's are required (See Photo)
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2N2219A	NPN General Purpose	TO 5	.23	.17	.16	.15
2N2369A	NPN High Speed Switch	TO 92	.23	.165	.155	.135
2N2905A	PNP Small Sig. General Purpose	TO 5	.22	.20	.18	.17
2N2907A	PNP General Purpose	TO 18	.21	.175	.165	.155
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2N3640	PNP Hi Speed Sat. Switch	TO 92	.24	.165	.14	.13
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2N3904	NPN Sm. Sig. GP Amp	TO 92	.23	.15	.14	.13
2N3906	PNP Sm. Sig. GP Amp	TO 92	.23	.15	.14	.13
2N4092	N ch. Fet Vp 20 BV40	TO 18	.48	.43	.41	.40
2N4093	N ch. Fet Vp 20 BV50	TO 18	.50	.45	.43	.42
2N4123	NPN Sm. Sig. GP Amp	TO 92	.23	.15	.14	.13
2N4125	PNP Sm. Sig. GP Amp	TO 92	.23	.15	.14	.13
2N4400	NPN GP Switch	TO 92	.23	.155	.145	.135
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4.000 MHz	HC18	4.95	20.000 MHz	HC18	4.95
5.000 MHz	HC18	4.95	32.000 MHz	HC18	4.95
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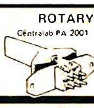
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74125	59
74126	59
74128	.49
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74148	1.99
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74151	99
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74155	99
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74157	99
74159	2.99
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74166	1.19
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4022	1.25
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4033	1.99
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4042	1.49
4043	1.49
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4046	2.49
4047	2.49
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319CN	1.29	711H
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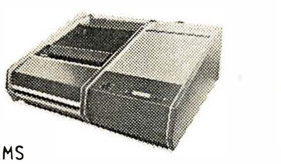
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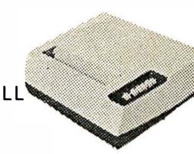


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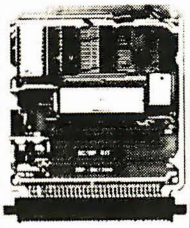


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Kit includes: 63 key keyboard, P.C. board, all required components and assembly manual with ASC II code list.

Optional: 1. Parity bit - add $1.00   Aluminum enclosure **$39.–**
2. Serial output - add $2.00

Note: If you already have this teletype keyboard you can have the kit without it for **$36.00 (reg. $39.85).** Dealer inquires invited.

SC/MP KEYBOARD KIT



$ 95.

This is a great kit for engineers and companies who don't have access to a Teletype. It is a low-cost teaching, learning, and developing tool for hobbyists, professors, students, and electronics entrepreneurs of all levels.

National's new Keyboard Kit now gives SC/MP Kit users a low-cost input/output capability. This new kit replaces the Teletype* normally required by the SC/MP Kit and allows users to evaluate the SC/MP CPU and to develop a variety of application software.

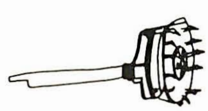
The heart of SC/MP Keyboard Kit is a ROM firmware package (512 bytes) called SCMPKB. The SCMPKB ROM replaces the "Kit Bug" ROM originally supplied with the SC/MP Kit and allows the effective use of the hexadecimal keyboard, to execute programs, to examine or modify the contents of memory and the SC/MP registers, and to monitor program performance.

There is a hole pattern for additional integrated circuits on the SC/MP Kit PC card. By following the simple instructions in the SC/MP Keyboard Kit users manual, one can add buffers, decoders, drivers, multiplexers, etc. Simply replace the Kit Bug ROM (supplied in the SC/MP Kit) with the new SCMPKB ROM, connect the pre-assembled Keyboard cable connector to the kit card, and you are ready to go!

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7450	.14
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7474	.23
7480	.40*
7493	.50
7495	.49
74107	.29
74109	.30
74116	1.50
74123	.45*
74141	.80*
74145	.75
74150	.60*
74151	.60
74152	.90
74155	.60
74157	.60
74160	.75
74161	.75*
74163	.75*
74165	.80
74173	1.25
74174	.75
74175	.75*
74177	.70
74180	.80
74181	1.50
74192	.70*
74193	.70*
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74198	1.25
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74S113	.80
74S139	1.50
74S140	.50
74S153	2.50
74S172	4.50
74S174	2.05
74S175	2.05*
74S181	4.50
74S197	2.20
74S257	1.50

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74H01	.20
74H04	.20
74H10	.20
74H11	.20
74H40	.20
74H51	.20
74H52	.20
74H74	.40
74H103	.50
74H106	.50

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74LS02	.29
74LS08	.29
74LS10	.29
74LS27	.30
74LS73	.45
74LS75	.65
74LS151	1.10
74LS153	1.10
74LS157	1.10
74LS161	1.50*
74LS163	1.50
74LS164	1.50
74LS174	1.10*
74LS175	1.50
74LS193	1.50
74LS221	1.50*
74LS251	1.50
74LS253	1.50
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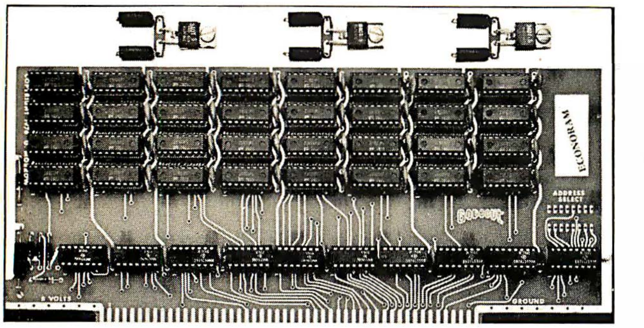
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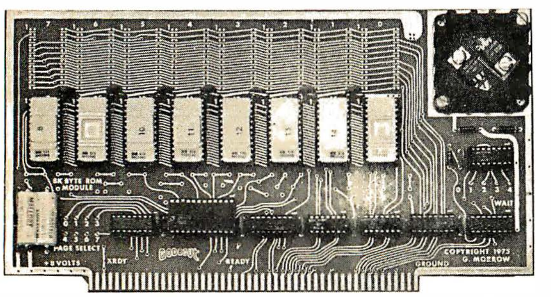
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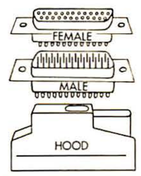
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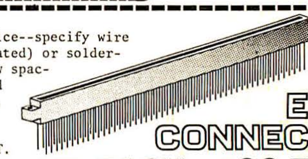
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XC22	Orange	4/$1	XC526	Orange	4/$1	XC556	Orange	4/$1	6/$1
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MAN 4	Common Cathode	.187	1.95	DL701	Common Anode-red ±	.300	.99
MAN 7	Common Anode	.300	1.25	DL704	Common Cathode	.300	.99
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MAN 74	Common Cathode	.300	1.50	FND70	Common Cathode	.250	.75
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16 pin	.22	.21	.20	36 pin	.60	.59	.58
18 pin	.29	.28	.27	40 pin	.63	.62	.61
22 pin	.37	.36	.35				

SOLDERTAIL STANDARD (TIN)

14 pin	$.27	.25	.24	28 pin	$.99	.90	.81
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18 pin	.35	.32	.30	40 pin	1.59	1.45	1.30
24 pin	.49	.45	.42				

SOLDERTAIL STANDARD (GOLD)

8 pin	$.30	.27	.24	24 pin	$.70	.63	.57
14 pin	.35	.32	.29	28 pin	1.10	1.00	.90
16 pin	.38	.35	.32	36 pin	1.75	1.40	1.26
18 pin	.52	.47	.43	40 pin	1.75	1.59	1.45

WIRE WRAP SOCKETS (GOLD) LEVEL #3

10 pin	$.45	.41	.37	24 pin	$1.05	.95	.85
14 pin	.39	.38	.37	28 pin	1.40	1.25	1.10
16 pin	.43	.42	.41	36 pin	1.59	1.45	1.30
18 pin	.75	.68	.62	40 pin	1.75	1.55	1.40

Plastic Push Button Switch



- 18 AWG Solid Wire - 5" Long
- .50 (wide) X .60 (high) ⅜-27 Thread
- 8 AMP @ 14 Volt - 1 AMP @ 110 Volt

		1-9	10-Up
J-188-1	Push On-Push Off	.59	.49
J-188-2	Normally Open	.59	.49
J-188-3	Normally Closed	.59	.49

MINATURE TOGGLE SWITCH



JMT-221	DPDT	on/off/on	$1.95
JMT-223	DPDT	on/none/on	$1.75
JMT-121	SPDT	on/off/on	$1.50
JMT-123	SPDT	on/none/on	$1.25



CLIPLITE NEW LED MOUNTING SYSTEM — to be used with XC556 LEDS — **SPECIFY COLORS** — RED — GREEN — AMBER — YELLOW **8/$1.49**

SPECIAL

50 PCS. RESISTOR ASSORTMENTS $1.75 PER ASST.

ASST. 1	5 ea.	10 OHM 27 OHM	12 OHM 33 OHM	15 OHM 39 OHM	18 OHM 47 OHM	22 OHM 56 OHM	1/4 WATT 5% = 50PCS.
ASST. 2	5 ea.	68 OHM 180 OHM	82 OHM 220 OHM	100 OHM 270 OHM	120 OHM 330 OHM	150 OHM 390 OHM	1/4 WATT 5% = 50 PCS.
ASST. 3	5 ea.	470 OHM 1.2K	560 OHM 1.5K	680 OHM 1.8K	820 OHM 2.2K	1K 2.7K	1/4 WATT 5% = 50 PCS.
ASST. 4	5 ea.	3.3K 8.2K	3.9K 10K	4.7K 12K	5.6K 15K	6.8K 18K	1/4 WATT 5% = 50 PCS.
ASST. 5	5 ea.	22K 56K	27K 68K	33K 82K	39K 100K	47K 120K	1/4 WATT 5% = 50 PCS.
ASST. 6	5 ea.	150K 390K	180K 470K	220K 560K	270K 880K	330K 820K	1/4 WATT 5% = 50 PCS.
ASST. 7	5 ea.	1M 2.7M	1.2M 3.3M	1.5M 3.9M	1.8M 4.7M	2.2M 5.6M	1/4 WATT 5% = 50PCS.

ASST. 8R Includes Resistor Assortments 1-7 (350 PCS.) **$10.95 ea.**

$5.00 Minimum Order — U.S. Funds Only
California Residents — Add 6% Sales Tax

Spec Sheets - 25¢ — Send 24¢ Stamp for 1977 Catalog
Dealer Discount Available — Request Pricing

NOW OPEN SATURDAYS

James ELECTRONICS

1021-A HOWARD AVE., SAN CARLOS, CA. 94070
PHONE ORDERS WELCOME — (415) 592-8097
All Advertised Prices Good Thru March

WIRE WRAP CENTER

HOBBY-WRAP TOOL-BW-630



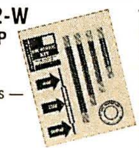
- Battery Operated (Size C)
- Weighs ONLY 11 Ounces
- Wraps 30 AWG Wire onto Standard DIP Sockets (0.25 inch)

Complete with built-in bit and sleeve

$34.95
(batteries not included)

WIRE-WRAP KIT — WK-2-W

WRAP • STRIP • UNWRAP



- Tool for 30 AWG Wire
- Roll of 500 ft. White 30 AWG Wire
- 50 pcs. each 1", 2", 3" & 4" lengths — pre-stripped white wire

$11.95



WIRE WRAP TOOL WSU-30

WRAP • STRIP • UNWRAP - $5.95

WIRE WRAP WIRE — 30 AWG

25 ft. min. $1.25 50 ft. $1.95 100 ft. $2.95 1000 ft. $15.00
SPECIFY COLOR — White - Yellow - Red - Green - Blue - Black

THUMBWHEEL SWITCHES

THUMBWHEEL SWITCH ONLY

Part No.	Description	Price
SF 12	Single Pole 10 Position	$2.50
SR 12	Decimal	3.00
SF 21	10 Position BCD only	2.50
SR 21		3.00

Ordering: Order desired switch or switches and add necessary accessories for your particular application

SF – Front Mount SR – Rear Mount

SERIES SF Front Mount Assembly



SERIES SR Rear Mount Assembly



ACCESSORIES

Part No.	Description	Price
SF-EP	End Plate (Pair)	.50
SF-DP	Divider Plate (each)	.40
SF-BB	Blank Body (each)	.40
SF-HB	Half Body (each)	.40

ACCESSORIES

Part No.	Description	Price
SR-EP	End Plates (pair)	$ .50
SR-DP	Divider Plate (each)	.40
SR-BB	Blank Body (each)	.40
SR-HB	Half Body (each)	.40



Permacel Electrical Tape

- ¾" (wide) X 66 ft (long) • All weather • Not import

$1.49 per roll — $12.50 per 10 roll package

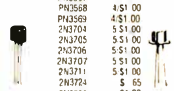
ZENERS — DIODES — RECTIFIERS

TYPE	VOLTS	W	PRICE	TYPE	VOLTS	W	PRICE
1N746	3.3	400mm	4/1.00	1N4005	600 PIV	1 AMP	10/1.00
1N751A	5.1	400m	4/1.00	1N4006	800 PIV	1 AMP	10/1.00
1N752	5.6	400m	4/1.00	1N4007	1000 PIV	1 AMP	10/1.00
1N753	6.2	400m	4/1.00	1N3600	50	200m	6/1.00
1N754	6.8	400m	4/1.00	1N4148	75	10m	15/1.00
1N959	8.2	400m	8/1.00	1N4154	35	10m	12/1.00
1N965B	15	400m	4/1.00	1N4305	75	25m	20/1.00
1N5232	5.6	500m	.28	1N4734	5.6	1w	.28
1N5234	6.2	500m	.28	1N4735	6.2	1w	.28
1N5235	6.8	500m	.28	1N4736	6.8	1w	.28
1N5236	7.5	500m	.28	1N4738	8.2	1w	.28
1N456	25	40m	6/1.00	1N4742	12	1w	.28
1N458	150	7m	6/1.00	1N4744	15	1w	.28
1N485A	180	10m	6/1.00	1N1183	50 PIV	35 AMP	1.60
1N4001	50 PIV	1 AMP	12/1.00	1N1184	100 PIV	35 AMP	1.70
1N4002	100 PIV	1 AMP	12/1.00	1N1185	150 PIV	35 AMP	1.50
1N4003	200 PIV	1 AMP	12/1.00	1N1166	200 PIV	35 AMP	1.80
1N4004	400 PIV	1 AMP	12/1.00	1N1168	400 PIV	35 AMP	3.00

SCR AND FW BRIDGE RECTIFIERS

C36D	15A @ 400V	SCR	$1.95
C38M	35A @ 200V	SCR	1.95
2N2328	1.6A @ 200V	SCR	.50
MDA 980-1	12A @ 50V	FW BRIDGE REC.	1.95
MDA980-3	12A @ 200V	FW BRIDGE REC	1.95

TRANSISTORS



MPS A05	5/$1.00			PN4249	4/$1.00
MPSA06	5/$1.00			PN4250	4/$1.00
2N2219A	3/$1.00	PN3567	3/$1.00	2N4400	4/$1.00
2N2221	4/$1.00	PN3568	4/$1.00	2N4401	4/$1.00
2N2222A	5/$1.00	PN3569	4/$1.00	2N4402	4/$1.00
2N2369	5/$1.00	2N3704	5/$1.00	2N4403	4/$1.00
2N2369A	4/$1.00	2N3705	5/$1.00	2N4409	5/$1.00
PN2415	5/$1.00	2N3706	5/$1.00	2N5086	4/$1.00
2N2484	4/$1.00	2N3707	5/$1.00	2N5087	4/$1.00
2N2906A	4/$1.00	2N3711	5/$1.00	2N5088	4/$1.00
2N2907A	5/$1.00	2N3724	$.65	2N5089	4/$1.00
2N2925	5/$1.00	2N3725	$1.00	2N5129	5/$1.00
2N3053	2/$1.00	2N3903	5/$1.00	2N5138	5/$1.00
2N3055	$.89	2N3904	4/$1.00	2N5139	5/$1.00
MJE3055	$1.00	2N3905	4/$1.00	2N5209	5/$1.00
MJE2955	$1.25	2N3906	4/$1.00	2N5951	5/$1.00
2N3392	5/$1.00	2N4013	3/$1.00	C106B1SCR	2/$1.00
2N3398	5/$1.00	2N4014	3/$1.00	2N5432	$2.00
		2N4123	10/$1.00		

CAPACITOR CORNER

50 VOLT CERAMIC DISC CAPACITORS

	1-9	10-49	50-100		1-9	10-49	50-100
10 pf	.05	.04	.03	.001µF	.05	.04	.035
22pf	.05	.04	.03	.0047µF	.05	.04	.035
47 pf	.05	.04	.03	.01µF	.05	.04	.035
100pf	.05	.04	.03	.022µF	.06	.05	.04
220 pf	.05	.04	.03	.047µF	.06	.05	.04
470pf	.05	.04	.035	.1µF	.12	.09	.075
100 VOLT MYLAR FILM CAPACITORS							
.001mf	.12	.10	.07	.022mf	.13	.11	.08
.0022	.12	.10	.07	.047mf	.21	.17	.13
.0047mf	.12	.10	.07	.1mf	.27	.23	.17
.01mf	.12	.10	.07	.22mf	.33	.27	.22
+20% DIPPED TANTALUMS (SOLID) CAPACITORS							
.1/35V	.28	.23	.17	1.5/35V	.30	.26	.21
.15/35V	.28	.23	.17	2.2/25V	.31	.27	.22
.22/35V	.28	.23	.17	3.3/25V	.31	.27	.22
.33/35V	.28	.23	.17	4.7/25V	.32	.28	.23
.47/35V	.28	.23	.17	6.8/25V	.36	.31	.25
.68/35V	.28	.23	.17	10/25V	.40	.35	.29
1.0/35V	.28	.23	.17	15/25V	.63	.50	.40
MINIATURE ALUMINUM ELECTROLYTIC CAPACITORS							
Axial Lead				Radial Lead			
.47/50V	.15	.13	.10	.47/25V	.15	.13	.10
1.0/50V	.16	.14	.11	.47/50V	.16	.14	.11
3.3/50V	.15	.13	.10	1.0/16V	.15	.13	.10
4.7/25V	.16	.14	.12	1.0/25V	.16	.14	.11
10/25V	.15	.13	.10	1.0/50V	.16	.14	.11
10/50V	.16	.14	.12	4.7/16V	.15	.13	.10
22/25V	.17	.15	.12	4.7/25V	.15	.13	.10
22/50V	.24	.20	.18	4.7/50V	.16	.14	.11
47/25V	.19	.17	.15	10/16V	.14	.12	.09
47/50V	.25	.21	.19	10/25V	.15	.13	.10
100/25V	.24	.20	.18	10/50V	.16	.14	.12
100/50V	.35	.30	.28	47/50V	.24	.21	.19
220/25V	.32	.28	.25	100/16V	.19	.15	.14
220/50V	.45	.41	.38	100/25V	.24	.20	.18
470/25V	.33	.29	.27	100/50V	.35	.30	.28
1000/16V	.55	.50	.45	220/16V	.23	.17	.16
2200/16V	.70	.62	.55	470/25V	.31	.28	.26



CRYSTALS



THESE FREQUENCIES ONLY

Part #	Frequency	Case/Style	Price
CY1A	1.000 MHz	HC33/U	$5.95
CY2A	2.000 MHz	HC33/U	$5.95
CY3A	4.000 MHz	HC18/U	$4.95
CY7A	5.000 MHz	HC18/U	$4.95
CY12A	10.000 MHz	HC18/U	$4.95
CY14A	14.31818 MHz	HC18U	$4.95
CY19A	18.000 MHz	HC18/U	$4.95
CY22A	20.000 MHz	HC18/U	$4.95
CY30B	32.000 MHz	HC18/U	$4.95

XR-2260KB Kit $27.95 **XR-2206KA Kit $17.95**

EXAR

WAVEFORM GENERATORS

XR-205	$8.40
XR-2206CP	4.49
XR-2207CP	3.85

STEREO DECODERS

XR-1310CP	$3.20
XR-1310EP	3.20
XR-1800P	3.20
XR-2567	2.99

MISCELLANEOUS

XR-2211CP	$6.70
XR-4136	99
XR-1468	3.85
XR-1488	5.80
XR-1489	4.80
XR-2208	5.20

TIMERS

XR-555CP	$ .39
XR-320P	1.55
XR-556CP	1.85
XR-2556CP	3.20
XR-2240CP	3.25

PHASE LOCKED LOOPS

XR-210	5.20
XR-215	6.60
XR-567CP	1.95
XR-567CT	1.70

CONNECTORS

PRINTED CIRCUIT EDGE-CARD

.156 Spacing-Tin-Double Read-Out

Bifurcated Contacts — Fits .054 to .070 P.C. Cards

15/30	PINS (Solder Eyelet)	$1.95
18/36	PINS (Solder Eyelet)	$2.49
22/44	PINS (Solder Eyelet)	$2.95
50/100 (.100 Spacing)	PINS (Solder Eyelet)	$6.95

25 PIN-D SUBMINATURE

DB25	PLUG	$3.25
DB25	SOCKET	$4.95

IMC 3½ DIGIT DVM KIT



This 0-2VDC .05 per cent digital voltmeter features the Motorola 3½ digit DVM chip set. It has a .4" LED display and operates from a single +5V power supply. The unit is provided complete with an injection molded black plastic case complete with Bezel. An optional power supply is available which fits into the same case as the 0-2V DVM allowing 117VAC operation.

A. 0-2V DVM with Case $49.95

B. 5V Power Supply $14.95

VECTOR WIRING PENCIL

Vector Wiring Pencil P173 consists of a handheld featherweight (under one ounce) tool which is used to guide and wrap insulated wire, fed off a self-contained replaceable bobbin, onto component leads or terminals installed on pre-punched "P" Pattern Vectorbord. Connections between the wrapped wire and component leads, pads or terminals are made by soldering. Complete with 250 FT of red wire **$9.95**

REPLACEMENT WIRE — BOBBINS FOR WIRING PENCIL

W36-3-A-Pkg. 3	250 ft. 36 AWG GREEN	$2.40
W36-3-B-Pkg. 3	250 ft. 36 AWG RED	$2.40
W36-3-C-Pkg. 3	250 ft. 36 AWG CLEAR	$2.40
W36-3-D-Pkg. 3	250 ft. 36 AWG BLUE	$2.40

1/16 VECTOR BOARD



	0.1" Hole Spacing Part No.	P-Pattern L	P-Pattern W	Price 1	Price 2-Up
PHENOLIC	64P44 062XXXP	4.50	6.50	1.72	1.54
	169P44 02XXXP	4.50	17.00	3.69	3.32
EPOXY GLASS	64P44 062	4.50	6.50	2.07	1.86
	84P44 062	4.50	6.50	2.56	2.31
	169P44 062	4.50	17.00	5.04	4.53
	169P84 062	8.50	17.00	9.23	8.26
EPOXY GLASS COPPER CLAD	169P44 062C1	4.50	17.00	6.80	6.12

HEAT SINKS





205-CB	Beryllium Copper Heat Sink with Black Finish for TO-5	$ .25
291-.36H	Aluminum Heat Sink for TO-220 Transistors & Regulators	$ .25
680-.75A	Black Anodized Aluminum	$1.60

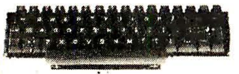
HEXADECIMAL ENCODER 19-KEY PAD



- 1 - 0
- ABCDEF
- Return Key
- Optional Key (Period)
- — Key

$10.95 each

63 KEY KEYBOARD

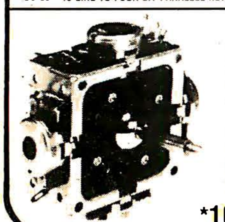


This keyboard features 63 unencoded SPST keys, unattached to any kind of P.C.B. A very solid molded plastic 13" x 4" base suits most applications.

$19.95

HD0165 16 LINE TO FOUR BIT PARALLEL KEYBOARD ENCODER $7.95

JOYSTICK



These joysticks feature four * potentiometers, that vary resistance proportional to the angle of the stick. Sturdy metal construction with plastics components only at the movable joint. Perfect for electronic games and instrumentation.

***5K Pots $6.95**

***100K Pots $7.95**

MICROPROCESSOR COMPONENTS

8080A	CPU	$19.95	MC6800L	8 Bit MPU	$35.00
8212	8 Bit Input/Output	4.95	MC6820L	Periph. Interface Adapter	15.00
8216	Bi-Directional Bus Driver	6.95	MC6810AP1	128 x 8 Static RAM	6.00
8224	Clock Generator/Driver	10.95	MC6830L7	1024 x 8 Bit ROM	18.00
8228	System Controller - Bus Driver	10.95			

CPU'S

8008	8 BIT CPU	$19.95
8080	Super 8008	24.95
8080A	Super 8008	19.95

SR'S

2504	1024 Dynamic	$ 3.95
2518	Hex 32 BIT	7.00
2519	Hex 40 BIT	4.00
2524	512 Dynamic	2.49
2525	1024 Dynamic	6.00
2527	Dual 256 BIT	3.95
2529	Dual 512 BIT	4.00
2532	Quad 80 BIT	3.95
2533	1024 Static	7.95
3341	Fifo	6.95
74LS670	16 x 4 Reg	3.95

UART'S

AY-5-1013	30K Baud	$5.95

ROM'S

2513	Char. Gen.	$ 9.95
2516	Char. Gen.	10.95
74S387	1024-Bit Programmable	1.95

RAM'S

1101	256 x 1	Static	$ 2.25
1103	1024 x 1	Dynamic	1.00
2101	256 x 4	Static	5.95
2102	1024 x 1	Static	1.75
2107	4096 x 1	Dynamic	9.95
2111	256 x 4	Static	6.95
7010	1024 x 1	MNOS	29.95
7489	16 x 4	Static	2.49
8101	256 x 4	Static	6.95
8111	256 x 4	Static	6.95
8599	16 x 4	Static	3.49
91L02	1024 x 1	Static	2.25
74200	256 x 1	Static	6.95
93421	256 x 1	Static	2.95
MM5262	2K x 1	Dynamic	.99

PROMS

1702A	2048	Famos	$12.95
5203	2048	Famos	14.95
82S23	32 x 8	Open C	5.00
82S123	32 x 8	Tristate	5.00
74S287	1024	Static	7.95
3601	256 x 4	Fast	3.95

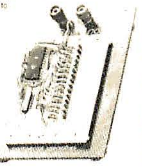
Special Programing Available — BIPOLAR PROM SPECIAL — Write or Call for Pricing

6330-1	256 Bit (32 x 8) Open Collector	2.95	6306-1	2048 Bit (512 x 4) Three State	9.95
6331-1	256 Bit (32 x 8) Three State	2.95	6340-1	2048 Bit (512 x 8) Open Collector	19.95
6300-1	1024 Bit (256 x 4) Open Collector	3.49	6341-1	2048 Bit (512 x 8) Three State	19.95
6301-1	1024 Bit (256 x 4) Three State	3.49	6352-1	4096 Bit (102 x 4) Open Collector	19.95
6305-1	2048 Bit (512 x 4) Open Collector	9.95	6353-1	4096 Bit (1024 x 4) Three State	19.95

Continental Specialties

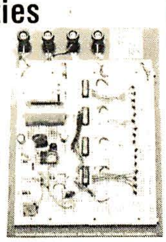
Proto Board 100 $19.95

Here's a low cost, big 10 IC capacity breadboard kit with all the quality of QT Sockets and the best of the Proto Board series ... complete down to the last nut, bolt and screw. Includes 2 QT-35S Sockets, 1 QT-35B Bus Strip, 2 5-way binding posts, 4 rubber feet, screws, nuts, bolts and easy assembly instructions.



COMPLETE KIT ....

THE MINI-BREADBOARD BUDGET KIT



Proto Board 104. Huge 3,060 solderless tie points, (4) 5-way binding posts, 32-14 pin DIP capacity, 9½" long x 8" wide **79.95**

Proto Board 101. Compact, inexpensive 10-14 pin DIP capacity 5.8" long x 4.5" wide **29.95**

Proto Board 102. Compact 12-14 pin DIP capacity 7" x 4½" **39.95**

Proto Board 103. 2,250 solderless tie points, (4) 5-way binding posts, 24-14 pin DIP capacity 9" x 6" **59.95**

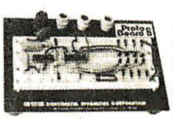
DESIGN MATE 1

CIRCUIT DESIGNER



You asked for it. HERE it IS! CSC's basic circuit designer to help you build and test ANY electronic circuit. Solid #22 AWG wire interconnects any discreet component without solder. Resistors, Transistors, Linear, Digital ICs in TO-5 DIP packages (from 8-40 pins). And, the components fit directly into Sockets and Bus strips instantly and easily. Plus, DESIGN MATE ONE's (DM-1) variable regulated power supply gives 5-15VDC up to 600ma (9 watts). Now that's design flexibility for you! You can even monitor the DM-1's internal power supply or external circuits thanks to the built-in 0-15V voltmeter. If you're into electronics, DM-1 is a must for your laboratory. It comes to you completely wired, tested and ready to use for only **$54.95**

PROTO BOARD 6



The PB-6 lets the user test and build circuits without soldering or patch cords — all interconnections between components are made with common #22 AWG hook-up wire. This quality breadboarding kit includes 630 component tie points at less than 2.5 cents each. It measures 6" long by 4" wide. Designed specially to Breadboard Microprocessor Circuits.

Proto Board 6 $15.95



Now trace signals or troubleshoot fast. Inject signals or wire unused circuits into existing boards. Scope probes, test leads lock onto Dynagrip inset. Plastic construction — no springs or pivots. Thousands of operations. Narrow throat for high density PC boards.

PC-14	14 pin Proto Clip	$3.60 ea
PC-16	16 pin Proto Clip	$3.80
PC-24	24 pin Proto Clip	$6.80

SPECIAL!

LOGIC MONITOR



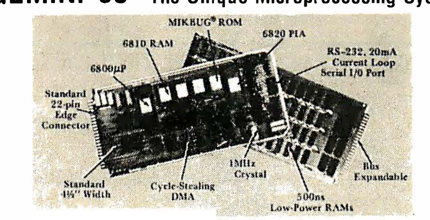
Simultaneously displays static and dynamic logic states of DTL, TTL, HTL or CMOS DIP ICs. Pocket size. **$84.95.**



QT Proto Strips

QT type	#holes	price
QT-59S	590	12.50
QT-59B	bus strip	2.50
QT-47S	470	10.00
QT-47B	bus strip	2.25
QT-35S	350	8.50
QT-35B	bus strip	2.00
QT-18S	180	4.75
QT-12S	120	3.75
QT-8S	80	3.25
QT-7S	70	3.00

GEMINI-68 The Unique Microprocessing System



ALL BOARDS BUS EXPANDABLE

Uses standard size 4½" wide boards, dual 22 pin edge connector

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FEATURES:

- 8 Digit Display
- 5 Functions consists of addition, subtraction, multiplication, division, percentage with constant on all functions, with full floating decimal point
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DIGITAL STOPWATCH

- Bright 6 Digit LED Display
- Times to 59 minutes 59.59 seconds
- Crystal Controlled Time Base
- Three Stopwatches in One Times Single Event — Split & Taylor
- Size 4.5" x 2.15" x .90" (4½ ounces)
- Uses 3 Penlite Cells.

Kit — $39.95
Assembled — $49.95
Heavy Duty Carry Case $5.95



DIGITAL QUARTZ CAR CLOCK



Complete kit from mounting bracket of the injection molded case down to the three conductor power cord and all components including MM5314 clock chip. Features quartz accuracy of .01%, six digit, .35" high LED display, and P.C. Boards. Works on any 12 volt system — motorcycles, boats, vans, motorhomes, autos, and trucks.

DIMENSIONS 4½" x 4" x 2"
12 or 24 HOUR MODE

Kit: $29.95
Assembled: $39.95

CASE ONLY (includes hardware, mounting bracket and bezel) **$5.95**

JE700 CLOCK

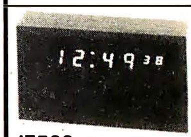


12 or 24 Hour

115 VAC

The JE700 is a low cost digital clock, but is a very high quality unit. The unit features a simulated walnut case with dimensions of 6" x 2½" x 1". It utilizes a MAN72 high brightness readout, and the MM5314 clock chip.

$17.95



This large digit clock (.6" hours & minutes, .3" seconds) features the MM5314 clock chip. It operates from 117 VAC, and will operate in either a 12 or 24 hour mode. The clock is complete with a walnut grain case, and has fast set, slow set, and hold time set features.

JE500 KIT - ALL COMPONENTS & CASE $34.95
WIRED & ASSEMBLED $39.95



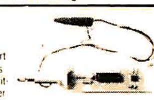
DIGITAL CLOCK KIT — 3½ INCH DIGITS

4 DIGIT KIT $49.95	4 DIGIT ASSEMBLED $59.95
6 DIGIT KIT $69.95	6 DIGIT ASSEMBLED $79.95

This clock features big 3½" high digits for viewing in offices, auditoriums, etc. Each digit is formed by 31 bright 0.2" LED's. The clock operates from 117VAC, has either 12 or 24 hr. operation. The 6 digit version is 27" x 3½" x 1½" and the 4 digit is 18" x 3½" x 1½". Kits come complete with all components, case and transformer.

Specify 12 or 24 Hour When Ordering

JE803 PROBE

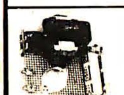


The Logic Probe is a unit which is for the most part indespensible in trouble shooting logic families TTL, DTL, RTL, CMOS. It derives the power it needs to operate directly off of the circuit under test, drawing a scant 10 mA max. It uses a MAN3 readout to indicate any of the following states by these symbols (HI) - 1 (LOW) - 0 (PULSE) - P. The Probe can detect high frequency pulses to 45 MHz. It can't be used at MOS levels or circuit damage will result.

$9.95 Per Kit

printed circuit board

T^2L 5V 1A Supply

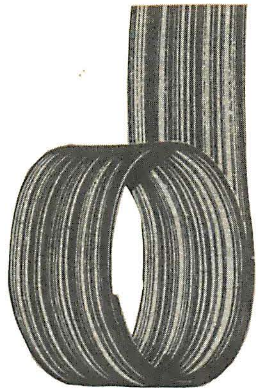


This is a standard TTL power supply using the well known LM309K regulator IC to provide a solid 1 AMP of current at 5 volts. We try to make things easy for you by providing everything you need in one package, including the hardware for only **$9.95 Per Kit**

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50 conductor, 28 gauge, 7 strands/conductor made by Spectra. Two conductors are paired & twisted and the flat ribbon made up of 25 pairs to give total of 50 conductors. May be peeled off in pairs if desired. Made twisted to cut down on "cross talk." Ideal for sandwiching PC boards allowing flexibility and working on both sides of the boards. Cost originally $12.00/ft.

SP-234-A $1.00 ft 50 cond. 10 ft/$9.00
SP-234-B .90 ft 32 cond. 10 ft/$8.00



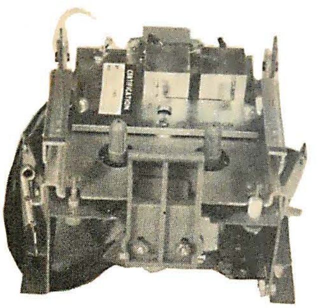
WIRE WRAP WIRE

TEFZEL blue #30 Reg. price $13.28/100 ft. Our price 100 ft. $2.00; 500 ft. $7.50.

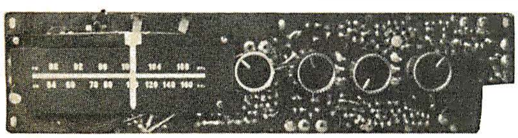
MULTI COLORED SPECTRA WIRE

Footage		10′	50′	100′
8 Cond.	#24	$2.50	9.00	15.00
12 "	22	3.00	11.00	18.00
14 "	22	3.50	13.00	21.00
29 "	22	7.50	28.00	45.00

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AM-FM solid state w/power supply for 115 volts AC. Has mike input, stereo tape or record player input, built-in loop stick. Ready to use, just add speakers $10.00

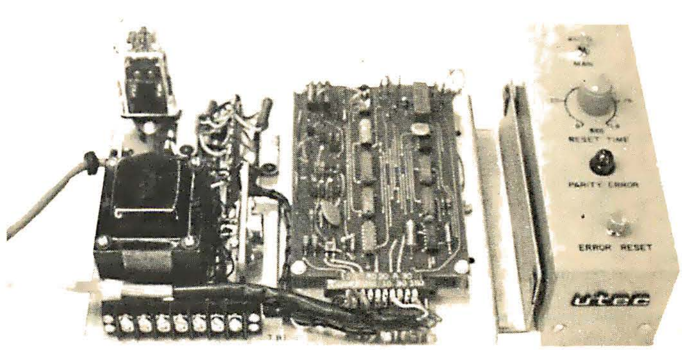


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Made for feeding into a computer terminal to query the credit balance of a customer with push-button entry and audio response. Power supply in separate case attached to base may be removed to use for other projects should you wish to scrap. Regular 115 volt input and output of plus 5 volts and plus & minus 12 V both DC & regulated. The phone is touch pad style, automatic electric pad. All sold "as is" 2 PC boards inside jammed with various parts & ICs including memory. Uses buffers ICs to accelerate & decelerate call traffic. Inquiry from Validier emerge as short bursts of Binary data signals. Normally used over leased phone lines at 200 times the capacity of messages. All appear to be excellent & complete. A Computer gadgeteers SPECTACULAR. And at a crazy price of only $18.00. 2 for $35.00
Ship. wgt. 10 lb. #SP-153-AL ea $18.00

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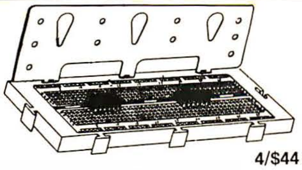
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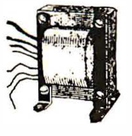


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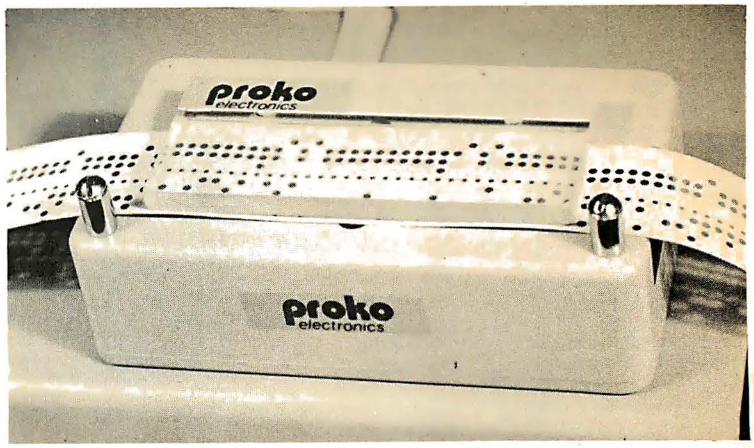
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7400	.16	7473	.35	74164	1.10
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7402	.21	7475	.50	74166	1.25
7403	.16	7476	.30	74170	2.10
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7409	.25	7490	.45	74179	.90
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7414	.70	7494	.80	74184	1.95
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7423	.37	74107	.40	74192	.90
7425	.30	74109	.90	74193	.90
7426	.30	74121	.40	74194	1.25
7427	.35	74122	.50	74195	.75
7430	.25	74123	.70	74196	1.25
7432	.30	74125	.60	74197	.90
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MM5017	1.90	2510A	2.00	2602	1.60	74LS10	.40	74L06	.30	74L93	1.70
MM5025	2.50	2511A	2.80	4002-1	7.50	74LS11	.50	74L08	.40	74L95	1.70
MM5026	2.50	2517V	1.25	4002-2	7.50	74LS12	.55	74L09	.40	74L98	2.80
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$149.^{KIT}

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As always, this kit includes all parts, all sockets, and complete instructions for ease of assembly. Because of our past experience with our 4K kit we suggest that you order early. All orders will be shipped on a strict first come basis. Dealers inquiries welcome on this item.

Kit shipped with 2 MHZ crystals for existing 500NS memory. Easily modified for faster RAM chips when the prices come down.

Z—80 Manual — $7.50 Separately.

Kit includes Zilog Manual and all parts.

JUMBO LED CAR CLOCK

$16.95 KIT

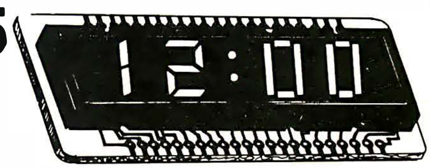
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STICK IT! in your clock in your DVM, etc.!

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KIT FEATURES:

A. 60HZ output with accuracy comparable to a digital watch.
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KIT INCLUDES CRYSTAL, DIVIDER IC, PC BOARD PLUS ALL OTHER NECESSARY PARTS & SPECS

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21L02—1 1K LOW POWER 500 NS STATIC RAM
TIME IS OF THE ESSENCE!

And so is power. Not only are our RAM'S faster than a speeding bullet but they are now very low power. We are pleased to offer prime new 21L02—1 low power and super fast RAM's. Allows you to STRETCH your power supply farther and at the same time keep the wait light off. **8 for $12.95**

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Prices in effect this month ONLY!

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No. TR1602B. 40 pin DIP

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7413	.45	7485	.88	74180	.70
7414	.70	7486	.30	74181	2.10
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5	0	1	2	3	4	5	6	7	8	9	10
6	0	1	2	3	4	5	6	7	8	9	10
7	0	1	2	3	4	5	6	7	8	9	10
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9	0	1	2	3	4	5	6	7	8	9	10
10	0	1	2	3	4	5	6	7	8	9	10
11	0	1	2	3	4	5	6	7	8	9	10
12	0	1	2	3	4	5	6	7	8	9	10
13	0	1	2	3	4	5	6	7	8	9	10
14	0	1	2	3	4	5	6	7	8	9	10
15	0	1	2	3	4	5	6	7	8	9	10
16	0	1	2	3	4	5	6	7	8	9	10
17	0	1	2	3	4	5	6	7	8	9	10
18	0	1	2	3	4	5	6	7	8	9	10
19	0	1	2	3	4	5	6	7	8	9	10
20	0	1	2	3	4	5	6	7	8	9	10
21	0	1	2	3	4	5	6	7	8	9	10
22	0	1	2	3	4	5	6	7	8	9	10
23	0	1	2	3	4	5	6	7	8	9	10
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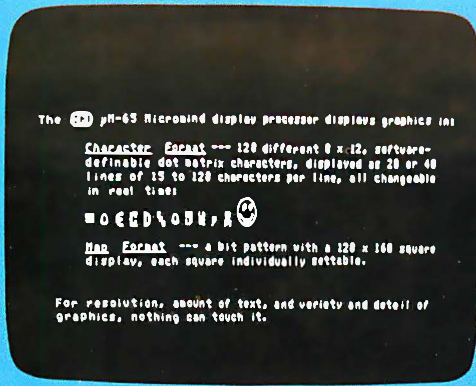
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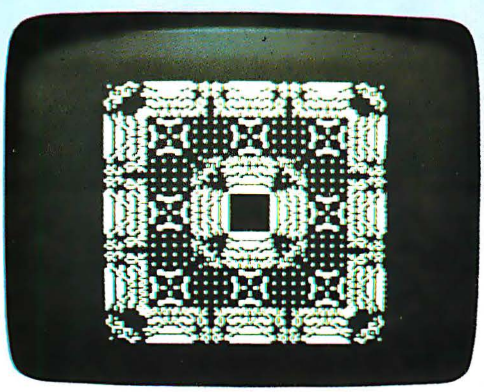
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